

Cloud properties retrieved from OCO-2

*Mark Richardson¹, Anthony Davis¹, Heather Cronk²,
Thomas Taylor², James McDuffie¹, Graeme Stephens^{1,2,3}*

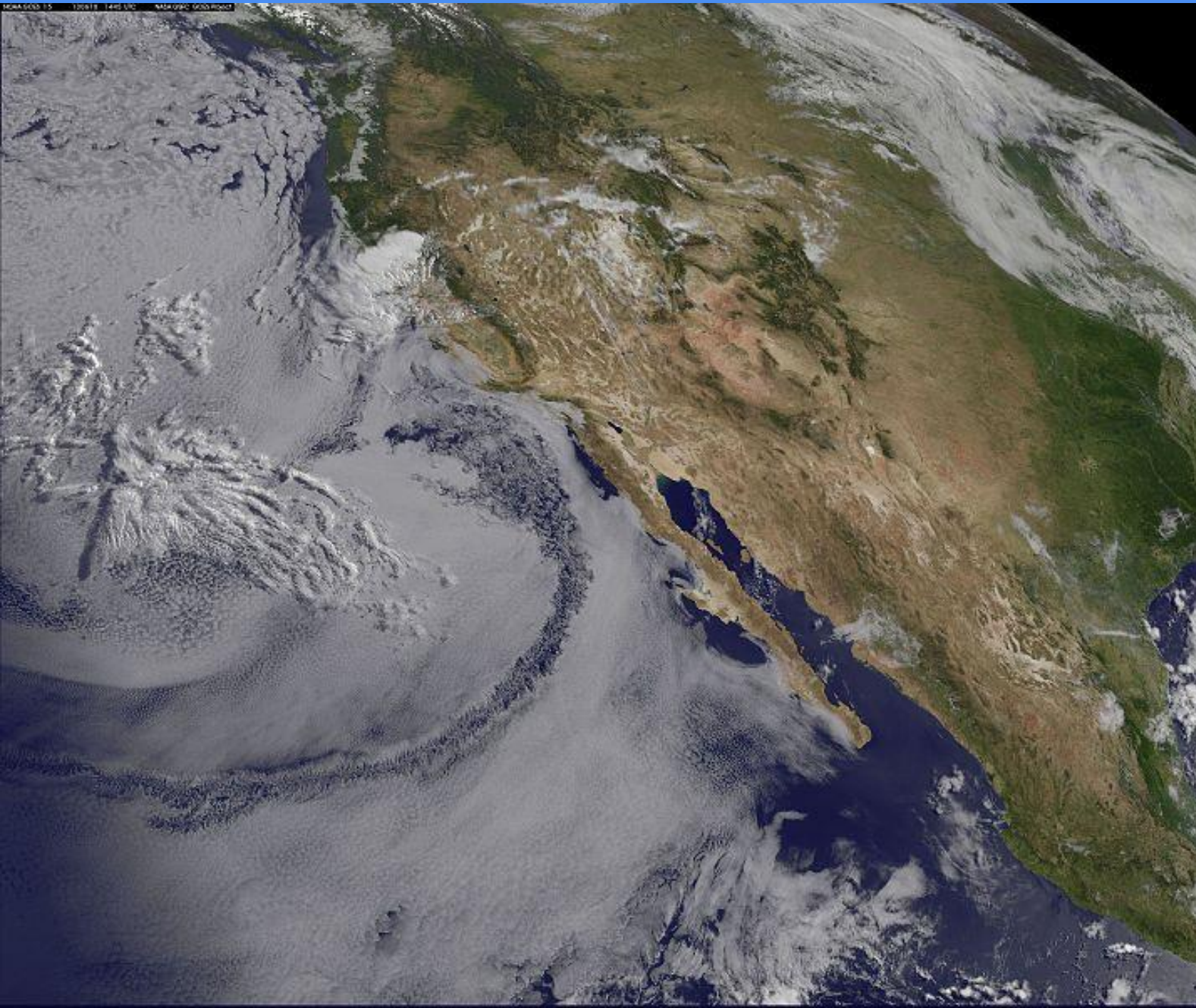
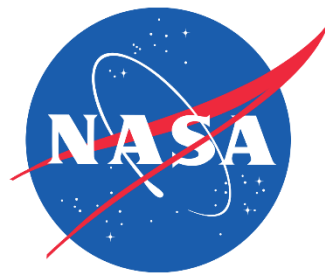
OCO-2 Science Team Meeting, Boulder, CO, 2017-10

¹Jet Propulsion Laboratory, California Institute of Technology, USA

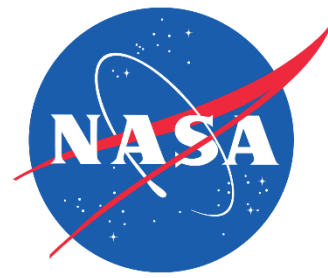
²Cooperative Institute for Research in the Atmosphere, Colorado State University, USA

³Department of Meteorology, University of Reading, UK

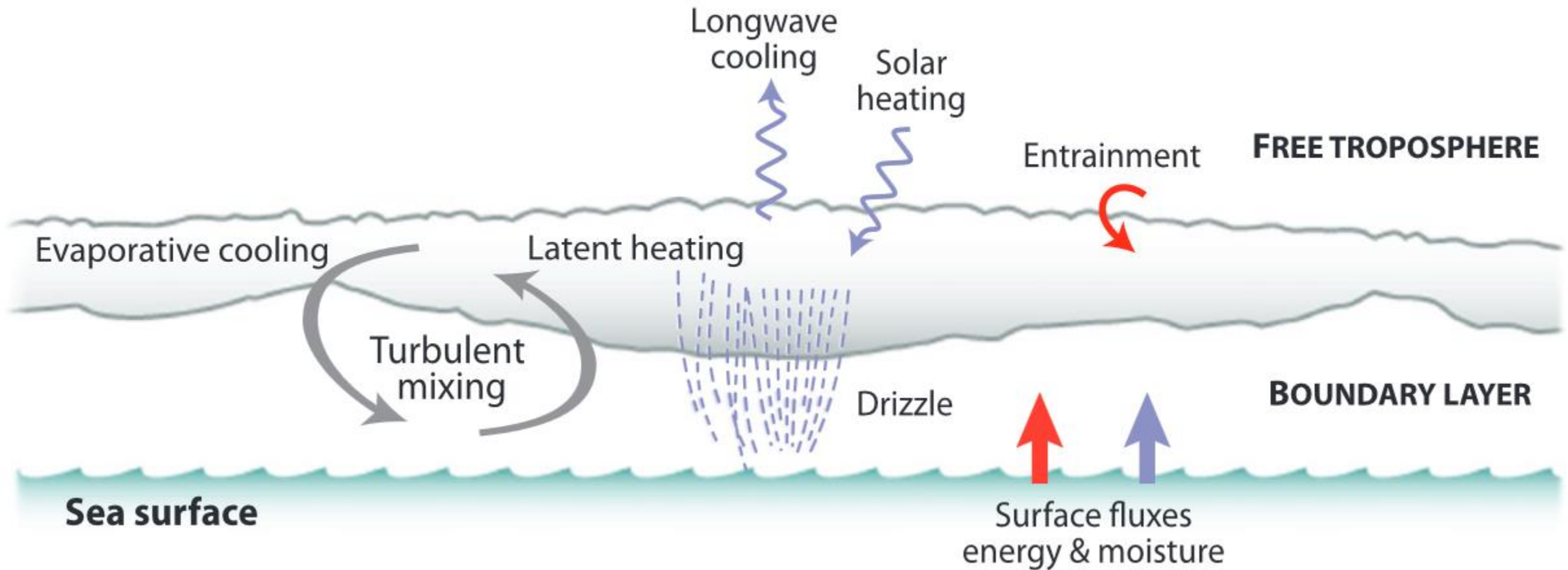
(1) Cloud retrievals from (mostly) OCO-2 A-band



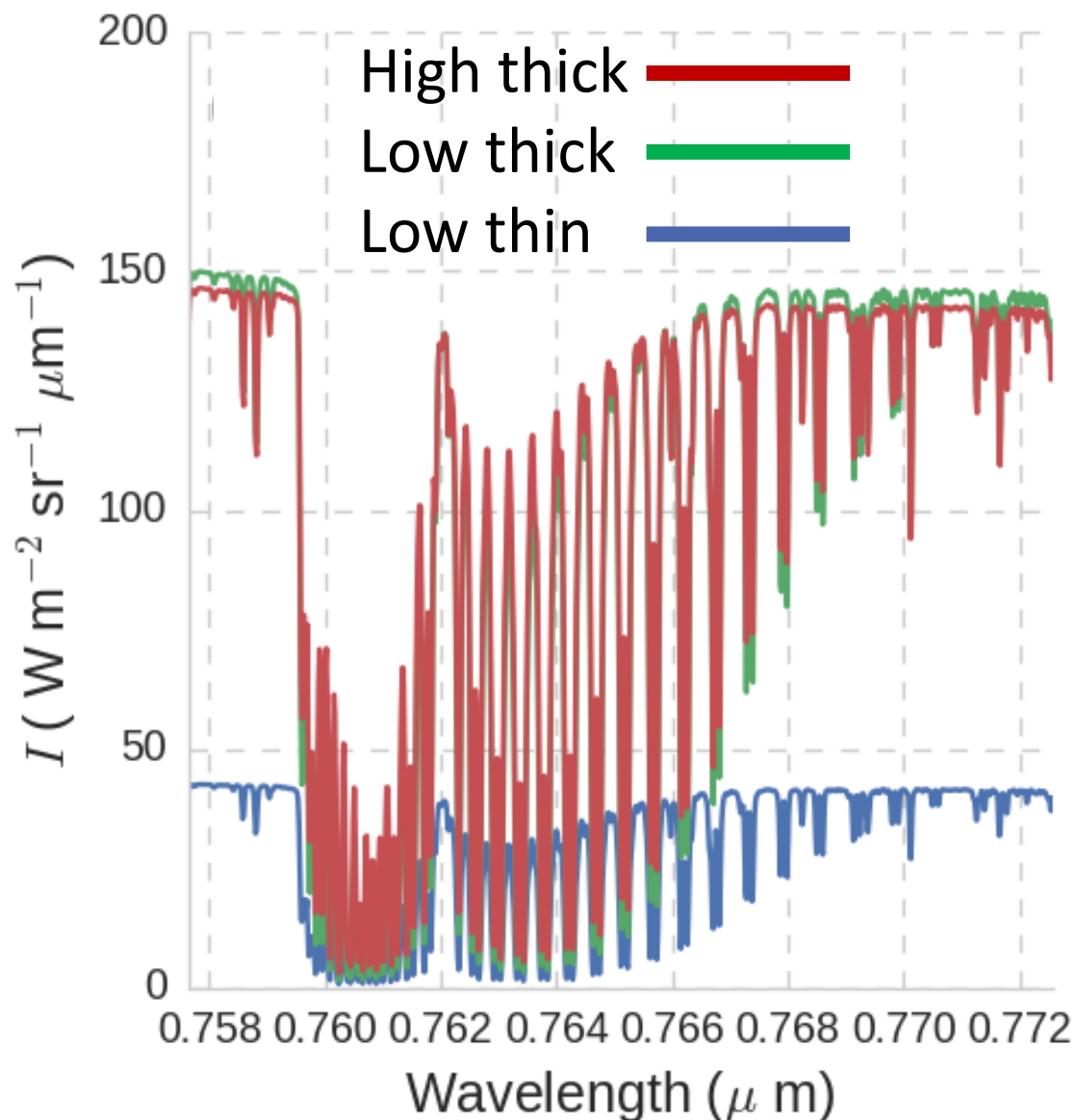
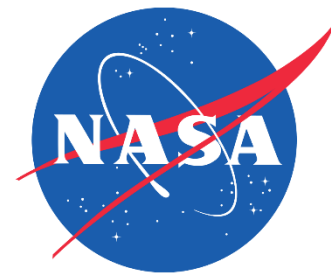
OCO-2's A-band can
tell us unique
information about
marine
stratocumulus clouds



These clouds are low and moist



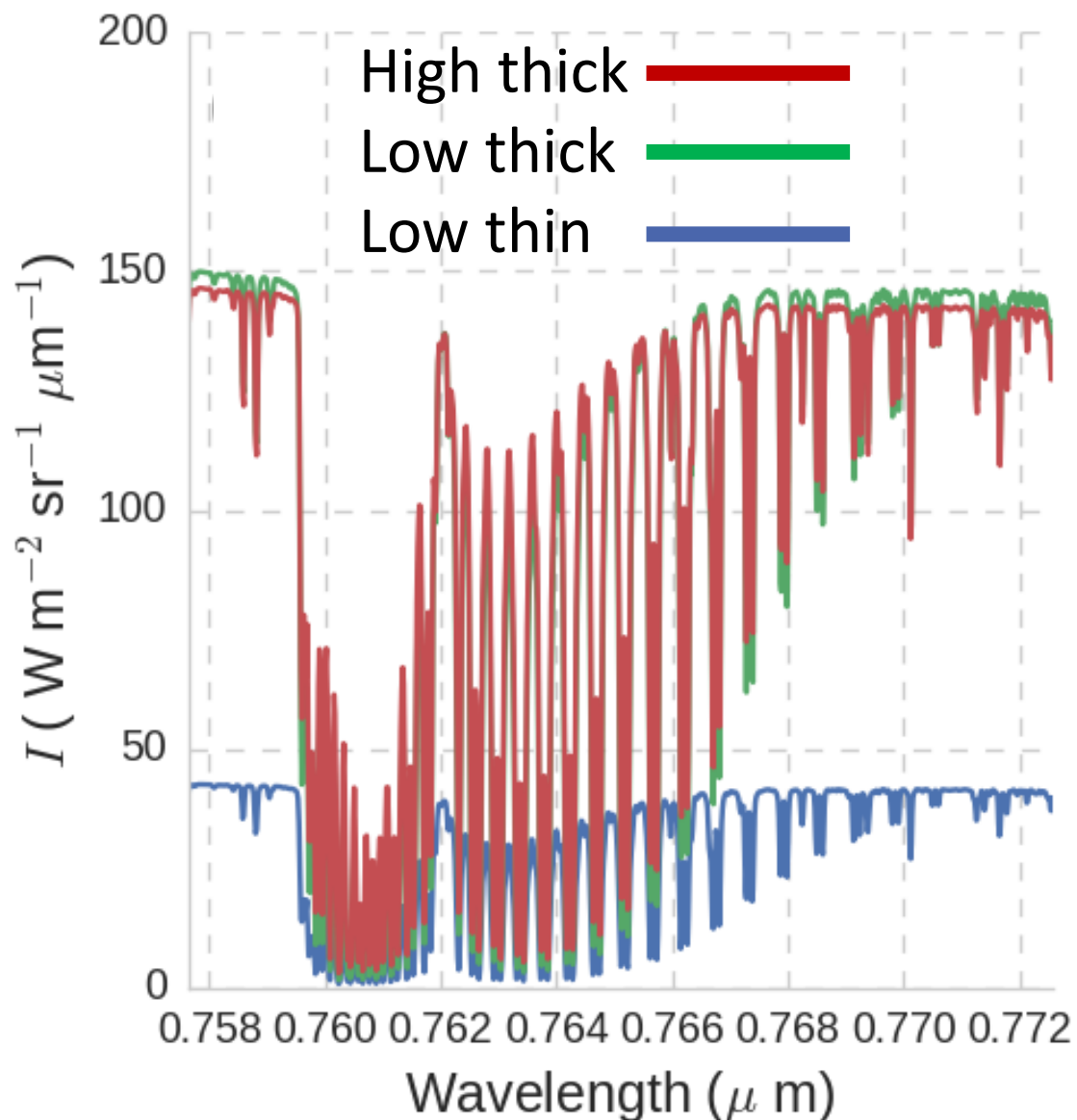
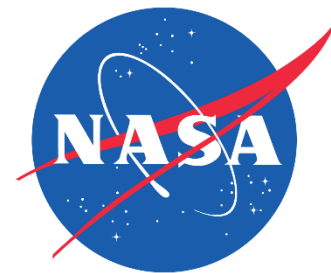
(3) OCO-2 A-band response to clouds



Optically thick clouds are more reflective (“brighter”)

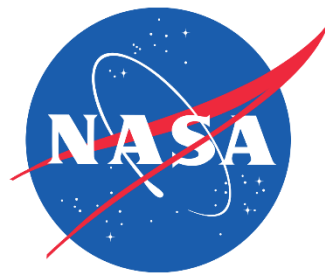
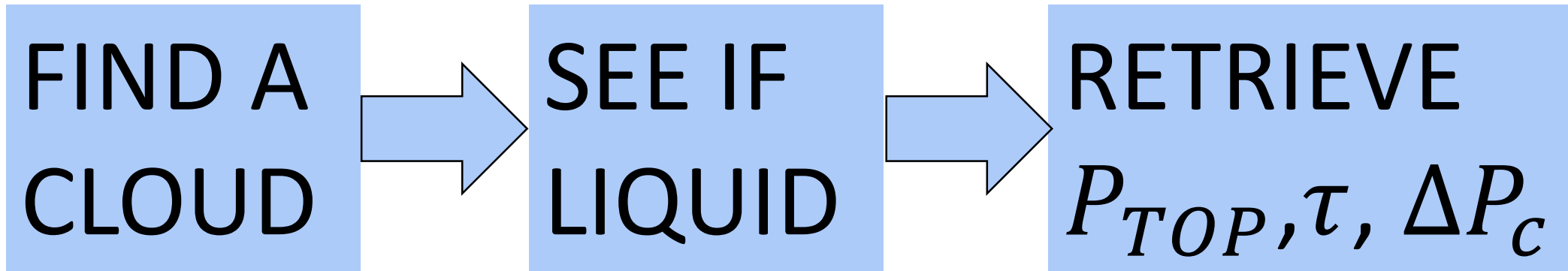
Optically thin clouds are less reflective (“darker”)

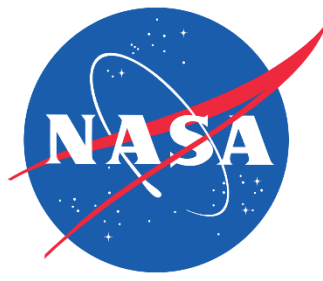
(4) OCO-2 A-band response to clouds



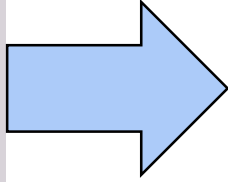
Deeper absorption bands means photons travelled further so cloud is *lower and/or thicker*

(5) Retrieval process

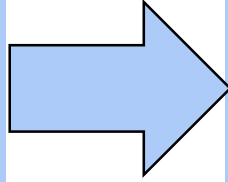




FIND A
CLOUD

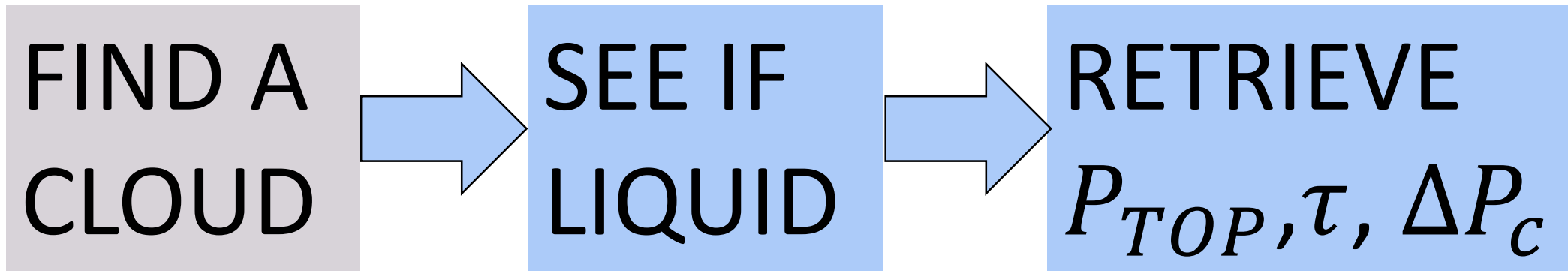
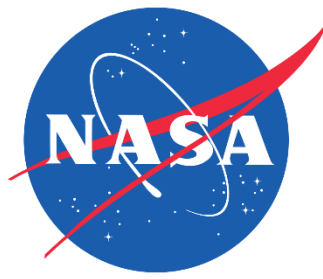


SEE IF
LIQUID



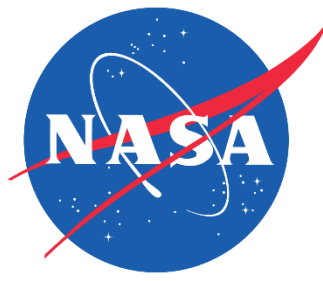
RETRIEVE
 $P_{TOP}, \tau, \Delta P_c$

Clouds are *much* brighter than ocean in nadir –
so assume cloud if OCO-2 sees bright scene

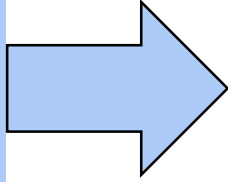


	MODIS CLOUD	MODIS CLEAR
OCO-2 CLOUD	56.5	6.5
OCO-2 CLEAR	7.2	29.8

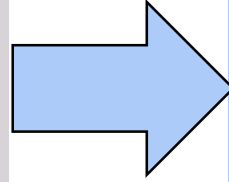
87.3 %
AGREEMENT
WITH MODIS



FIND A
CLOUD



SEE IF
LIQUID

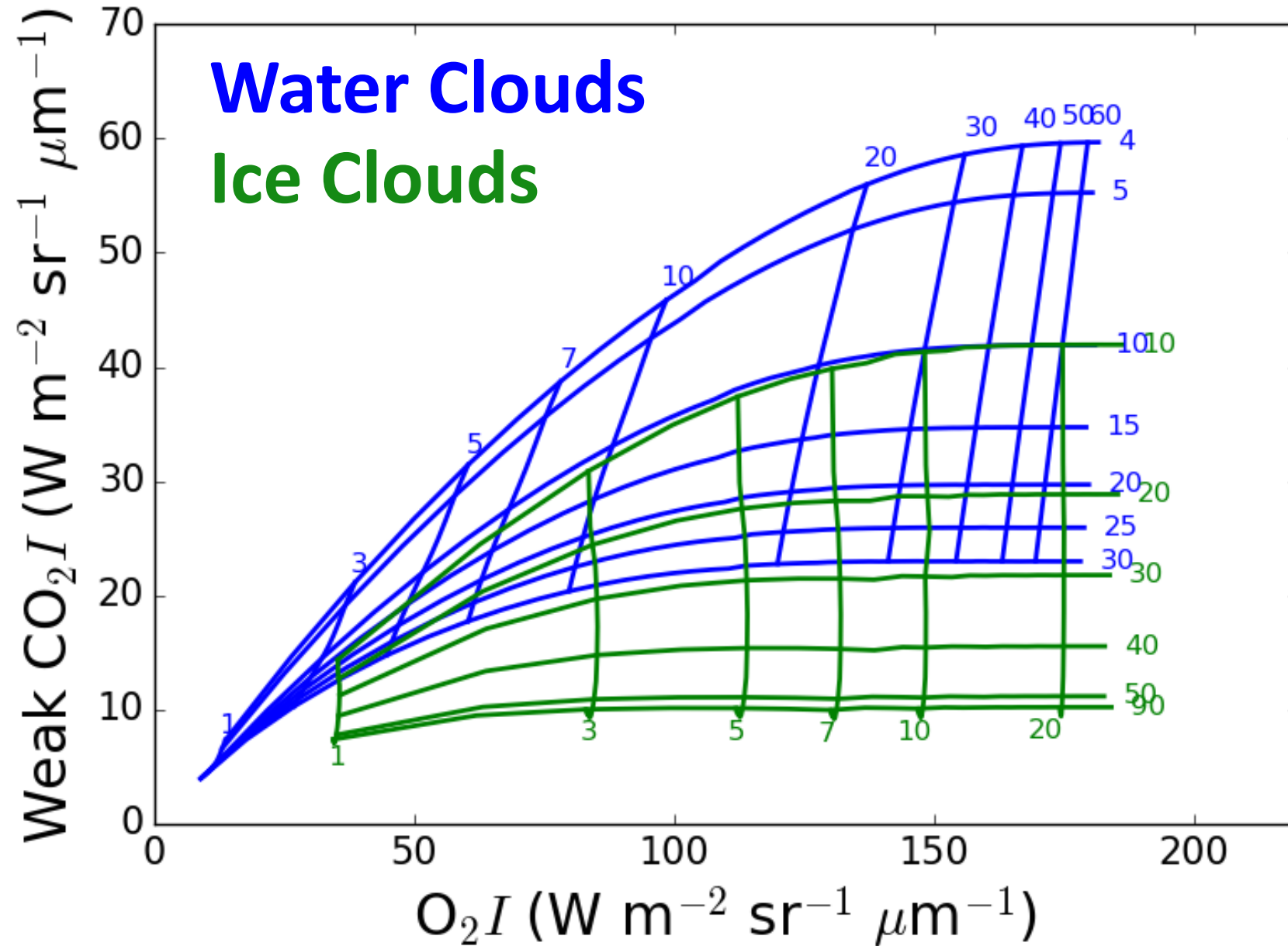
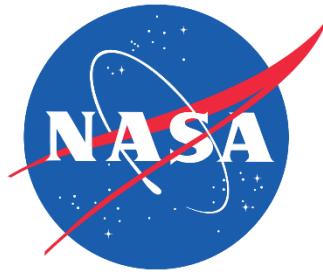


RETRIEVE
 $P_{TOP}, \tau, \Delta P_c$

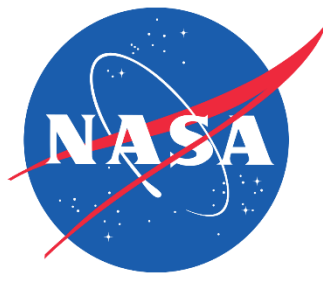
Ice absorbs more in weak CO₂ band

I use this and get ~93 % agreement with MODIS
cloud phase

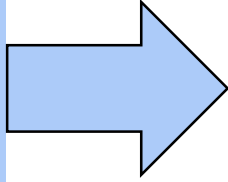
(4) Process



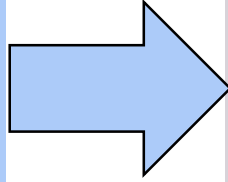
I agree with MODIS ~93 % of the time



FIND A
CLOUD



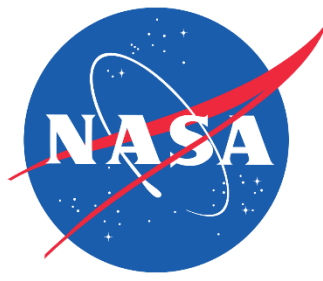
SEE IF
LIQUID



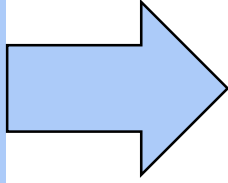
RETRIEVE
 $P_{TOP}, \tau, \Delta P_c$

ΔP_c is cloud thickness in hPa.

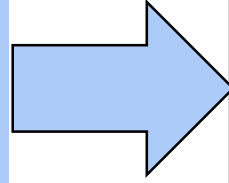
Thicker for given τ means droplets are further apart – affects reflectance and precipitation



FIND A
CLOUD



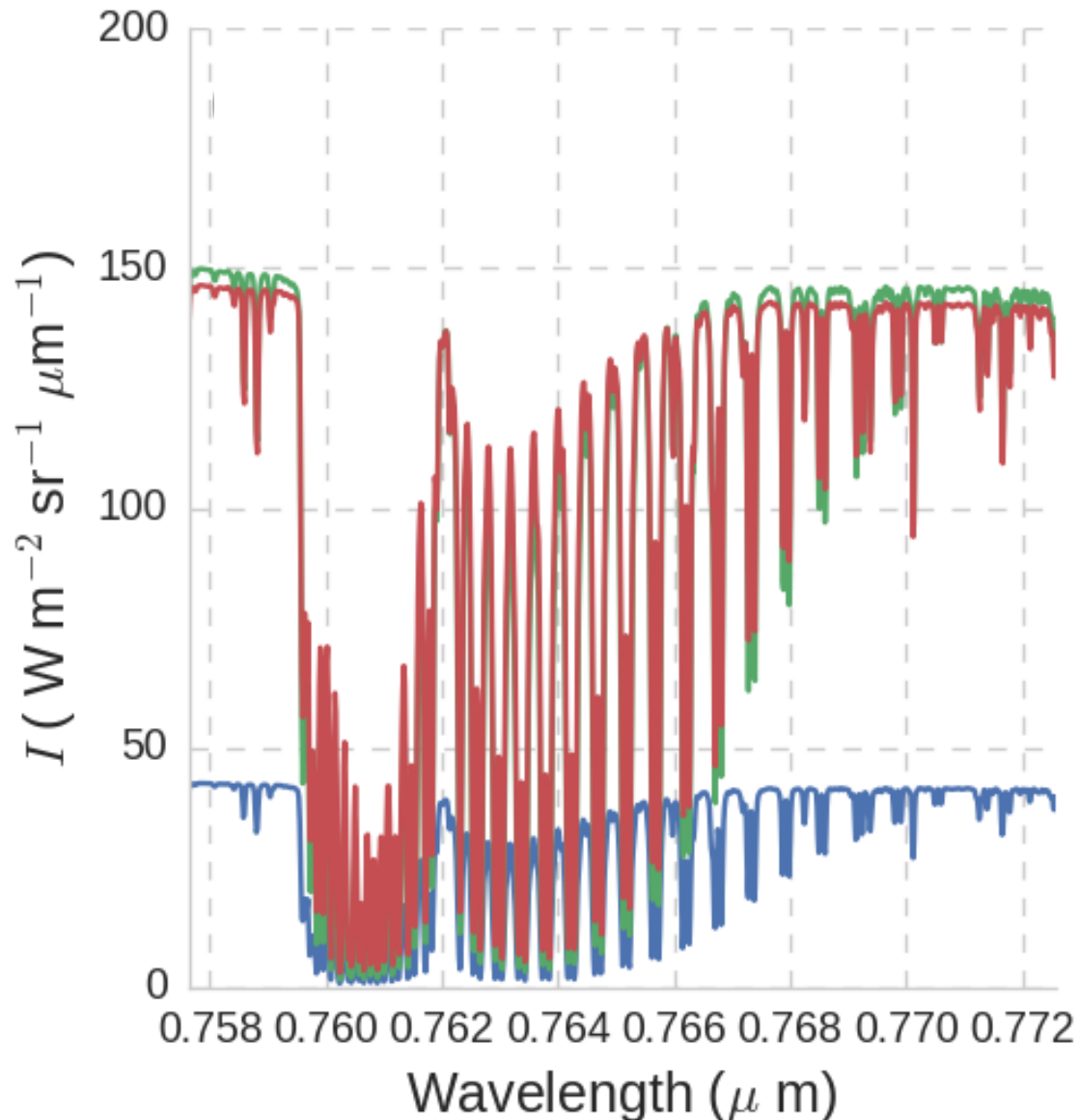
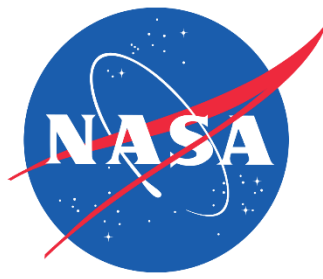
SEE IF
LIQUID



RETRIEVE
 $P_{TOP}, \tau, \Delta P_c$

Simulating all ~850 A-band channels
makes the retrieval slooooooooooooo

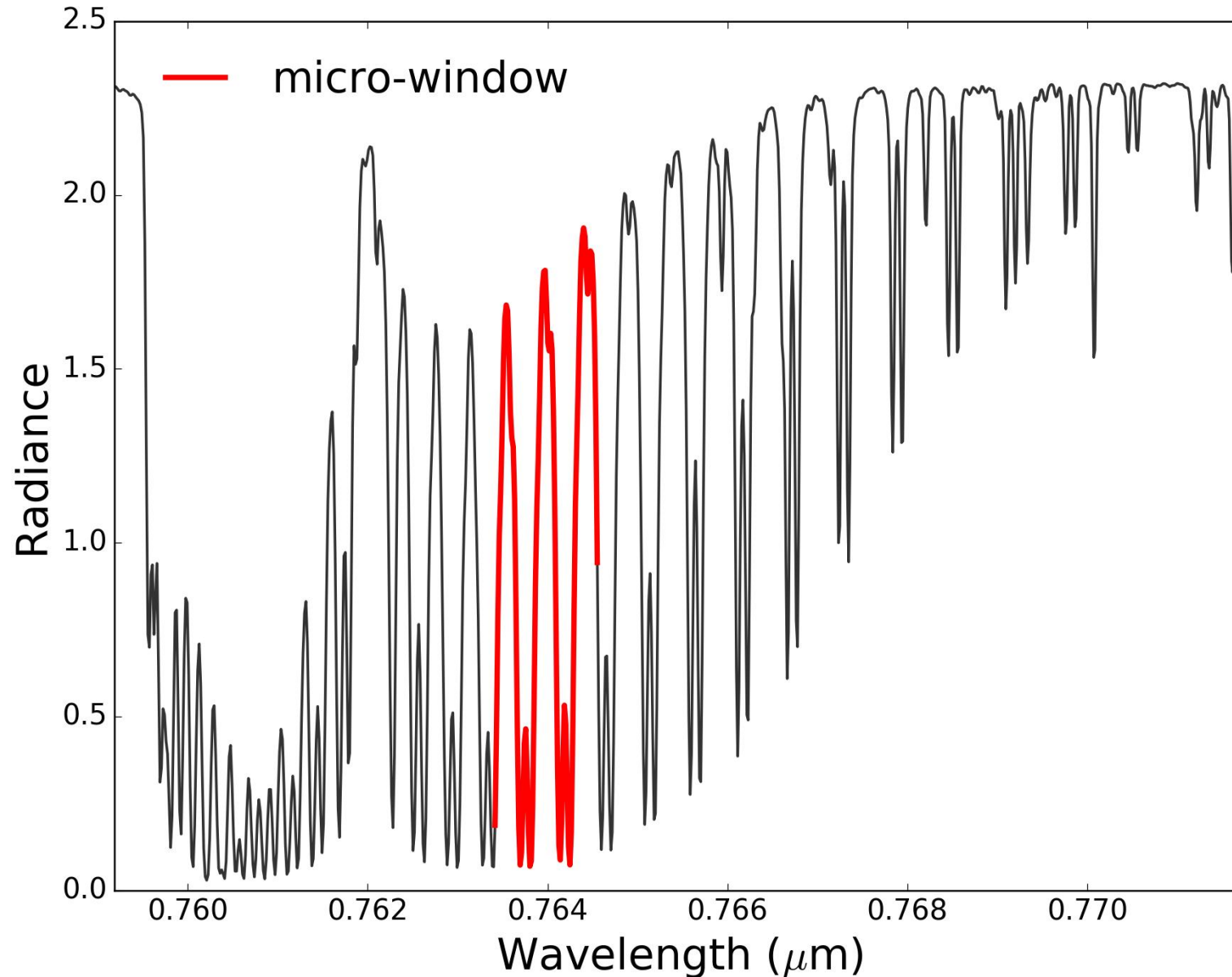
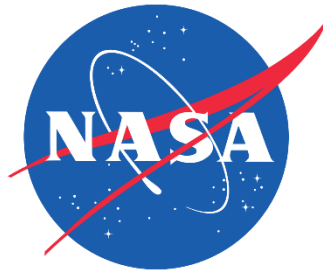
(3) OCO-2 A-band response to clouds



Note that “shape” of spectrum doesn’t change much

e.g. “bright” channels all say the same thing...

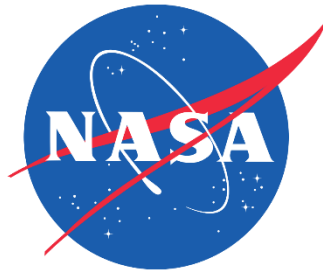
(4) Process



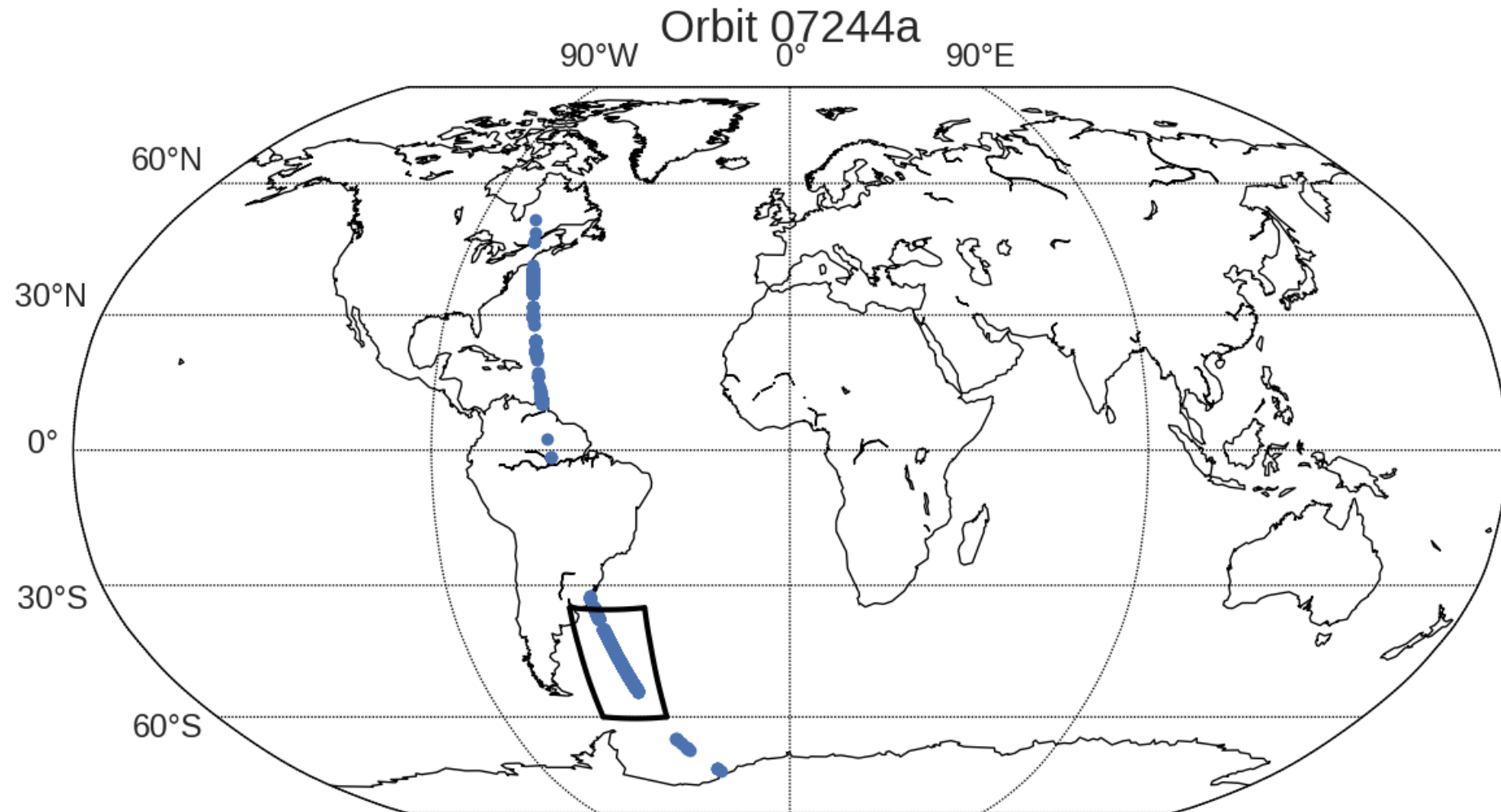
75 red channels
contain 70 % of full
spectrum information

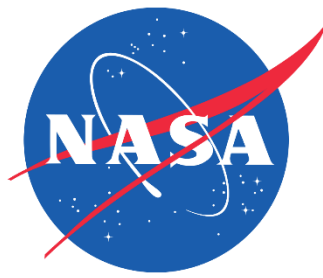
Richardson & Stephens (2017)
AMTD 10.5194/amt-2017-314

(5) One orbit example

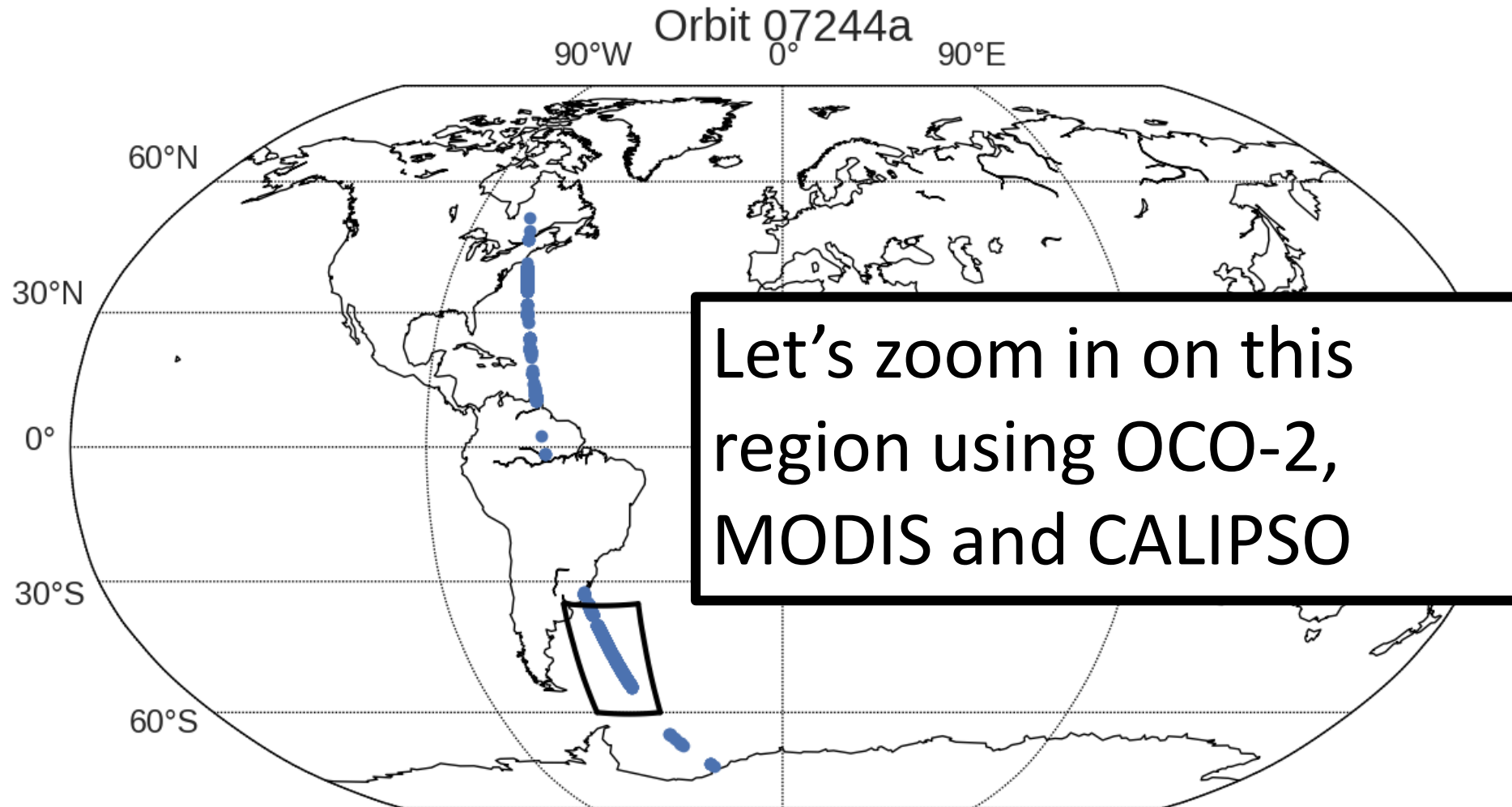


November 2015

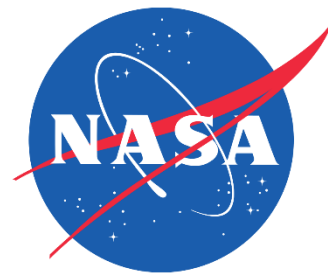




November 2015



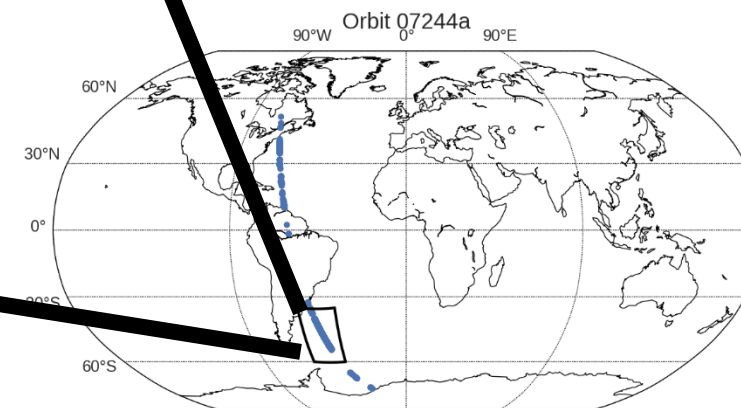
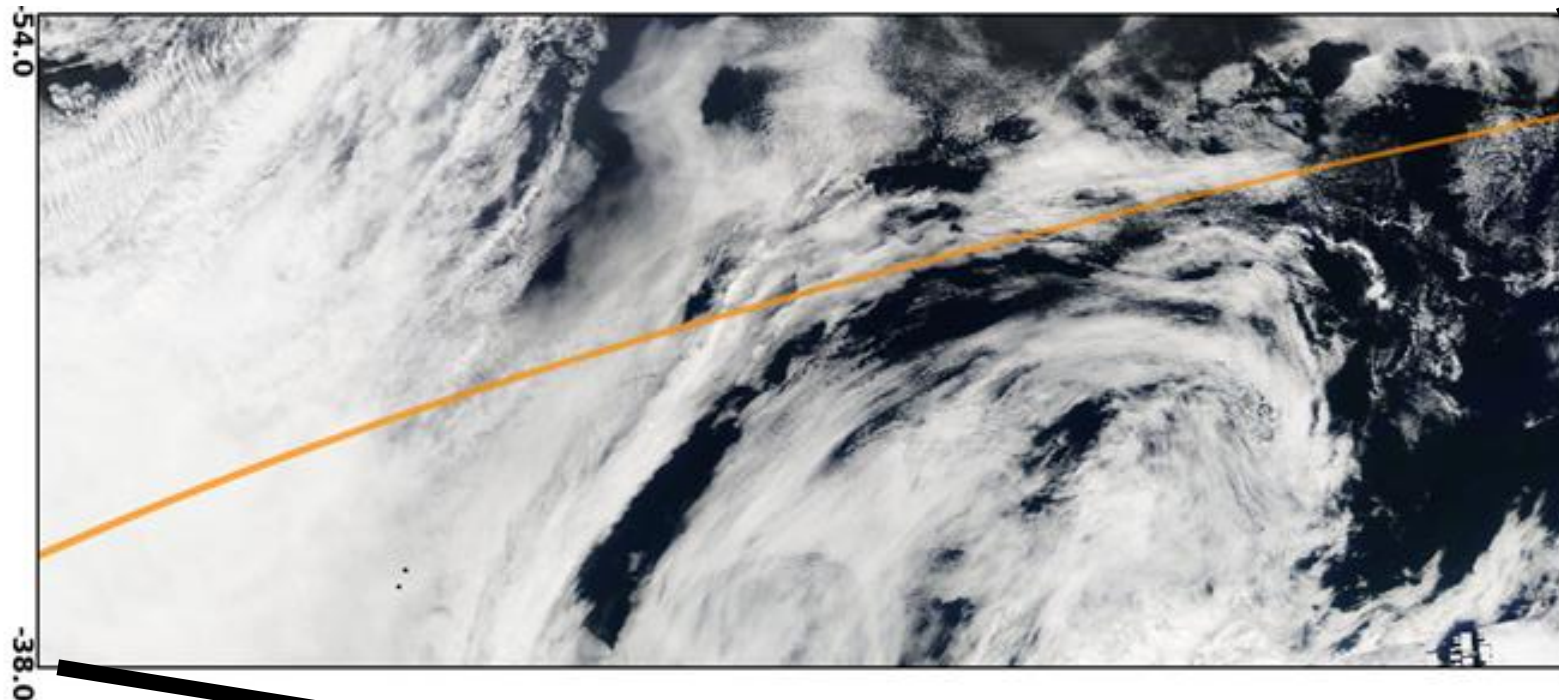
(6) View from MODIS



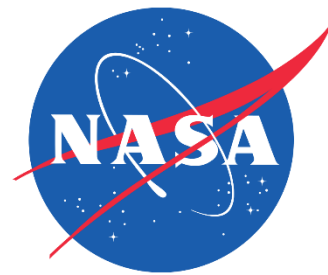
Note rotation, left-to-right is south-to-north

60 °S

35 °S



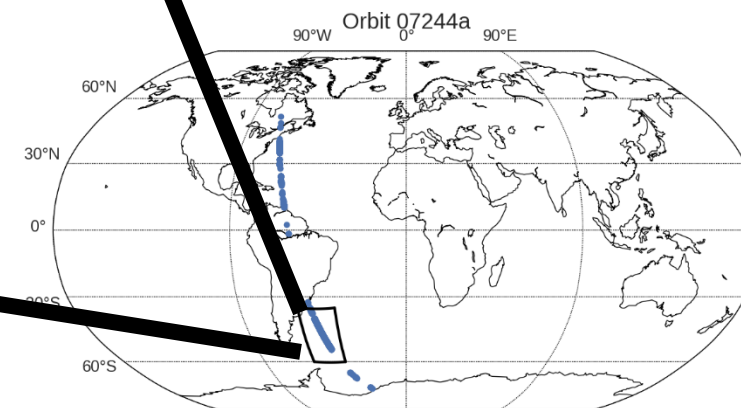
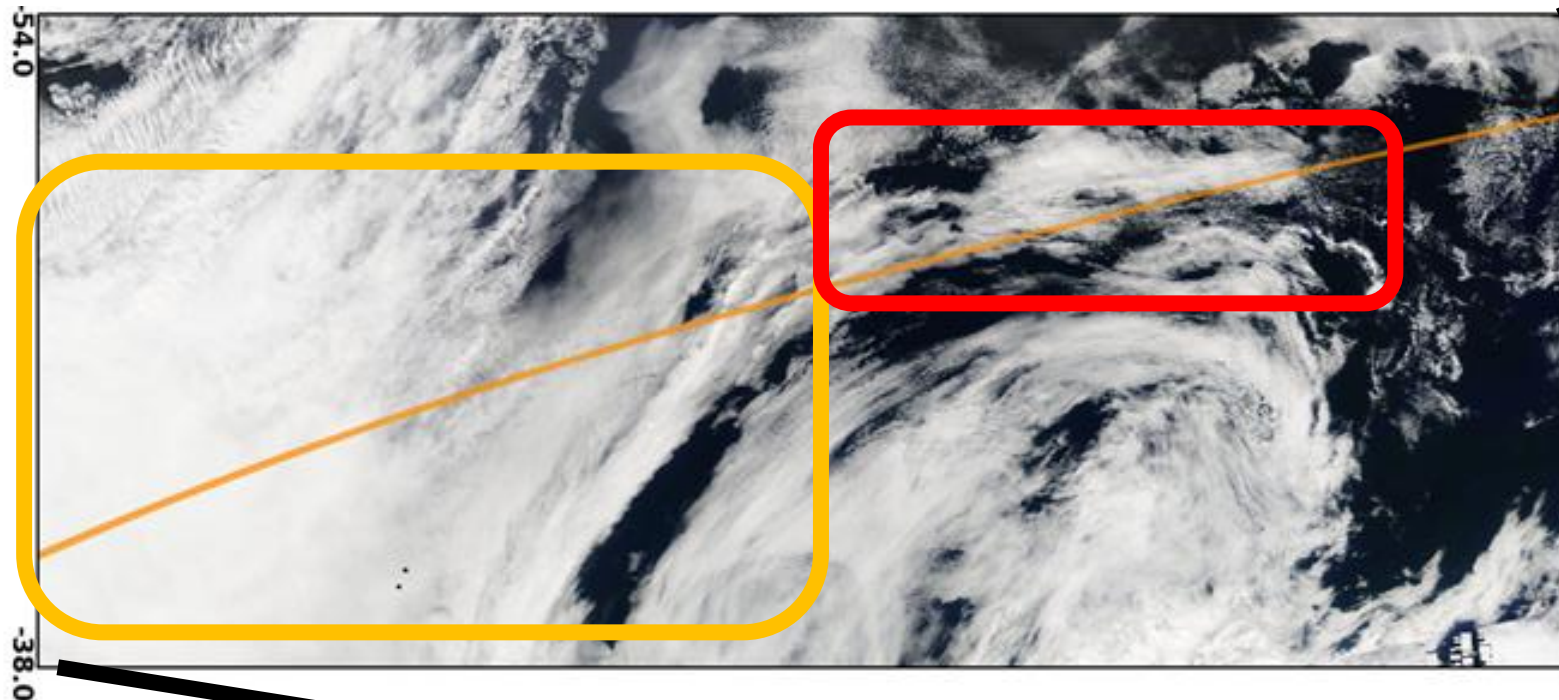
(6) View from MODIS



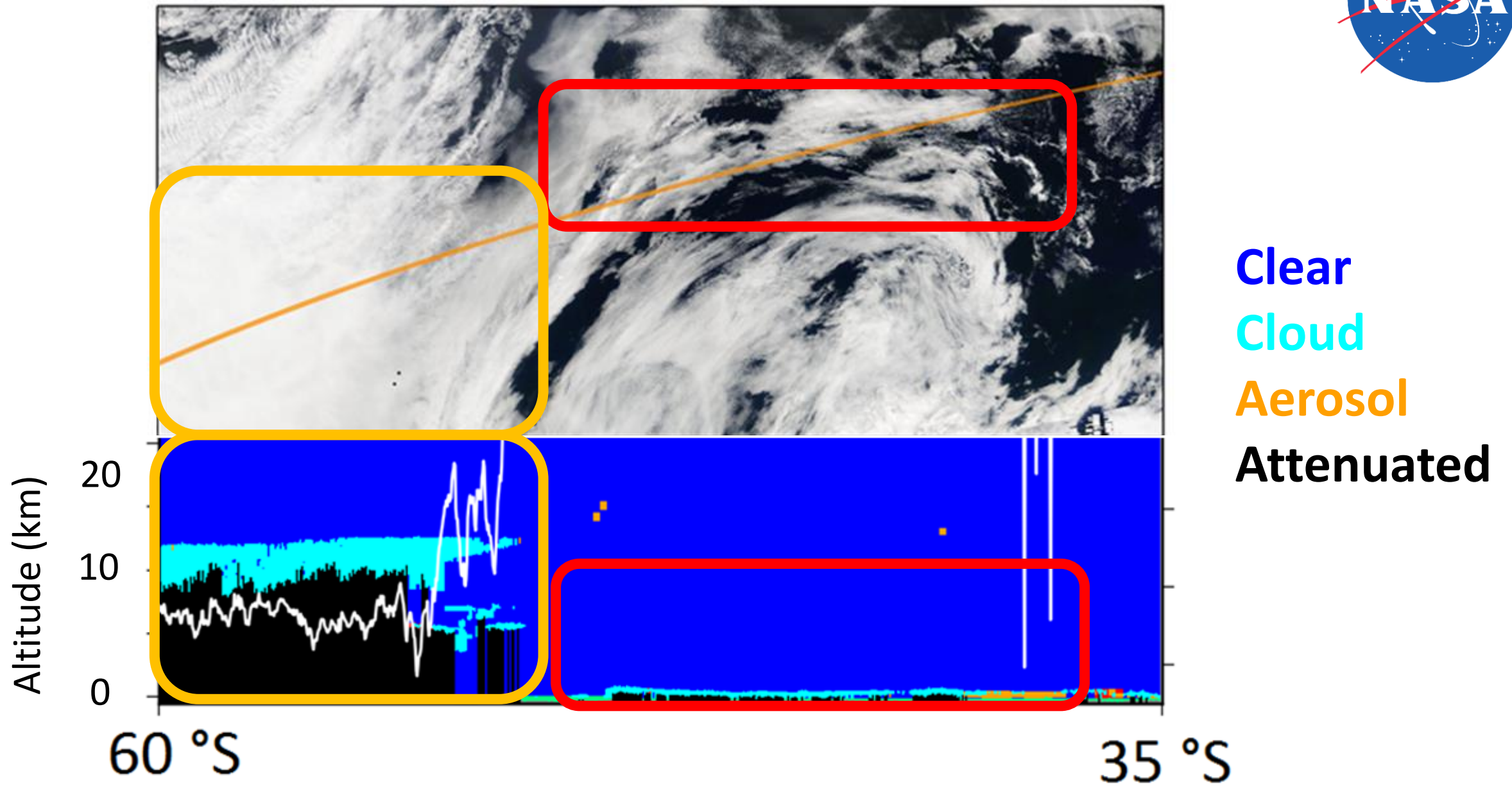
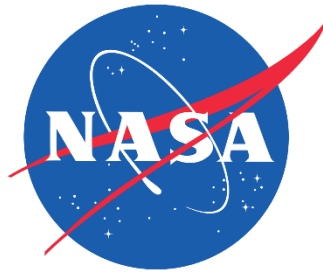
Note rotation, left-to-right is south-to-north

60 °S

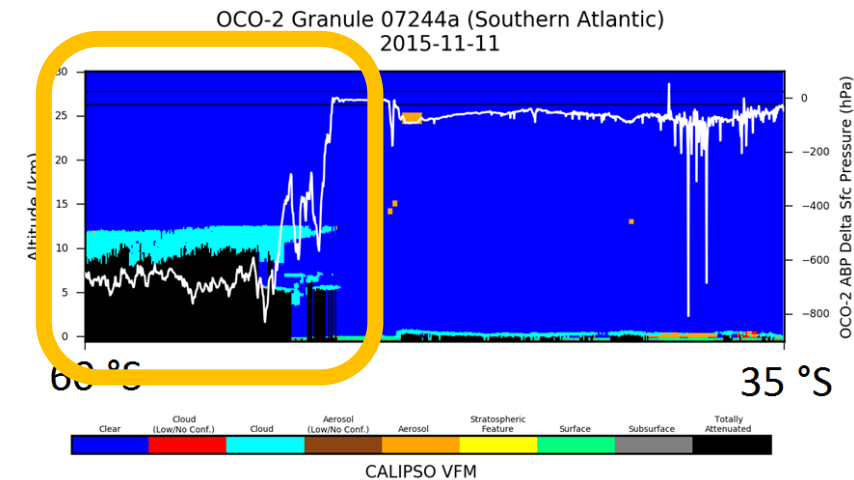
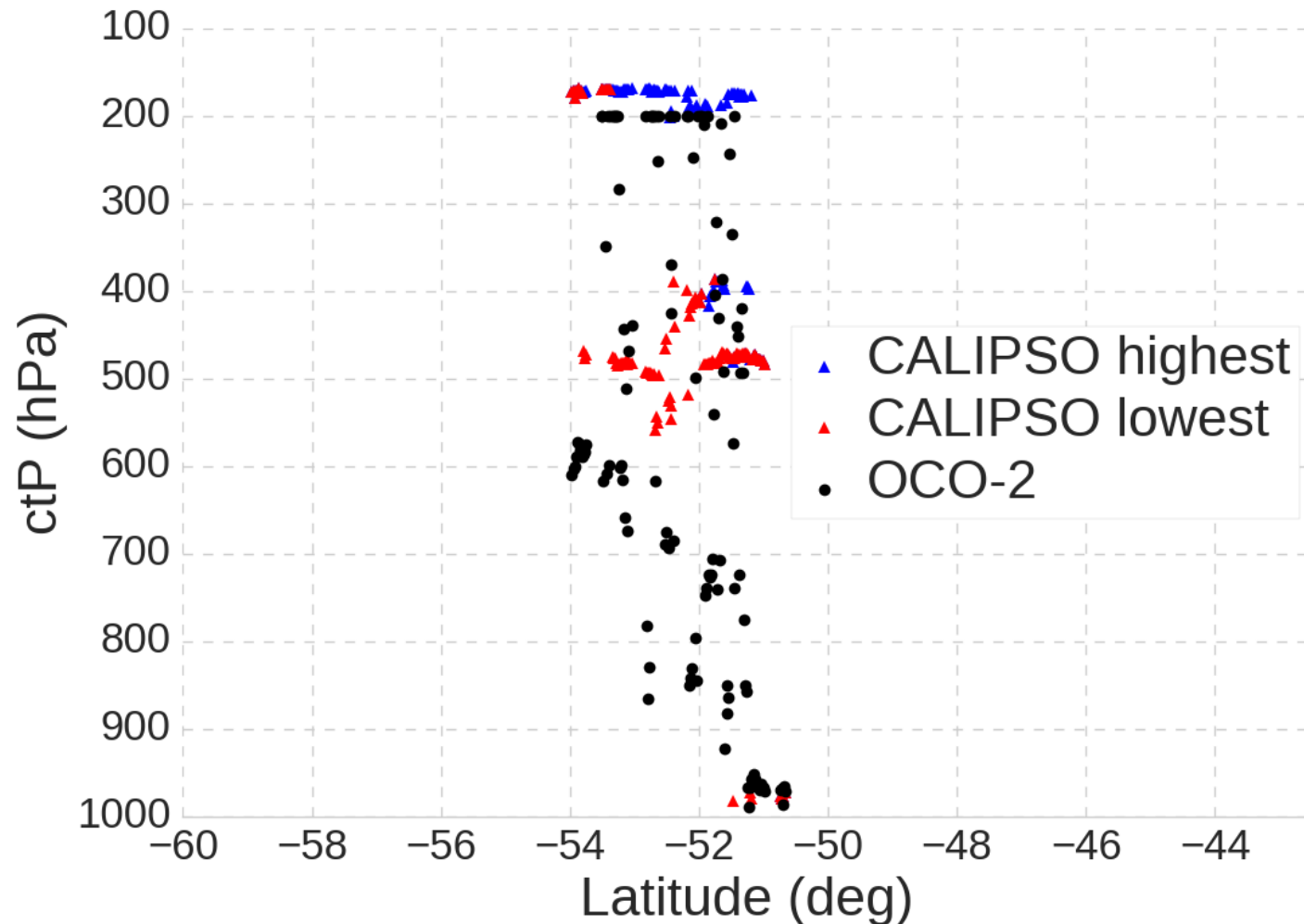
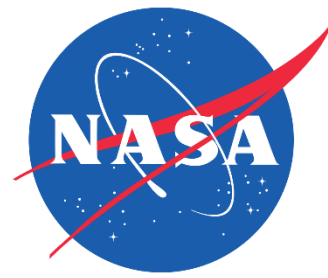
35 °S



(7) Bringing in CALIPSO

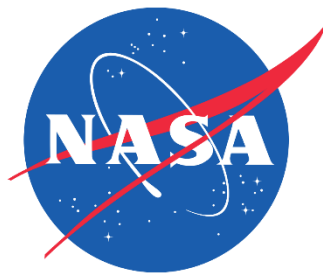


(8) OCO-2 retrievals with overlying cirrus

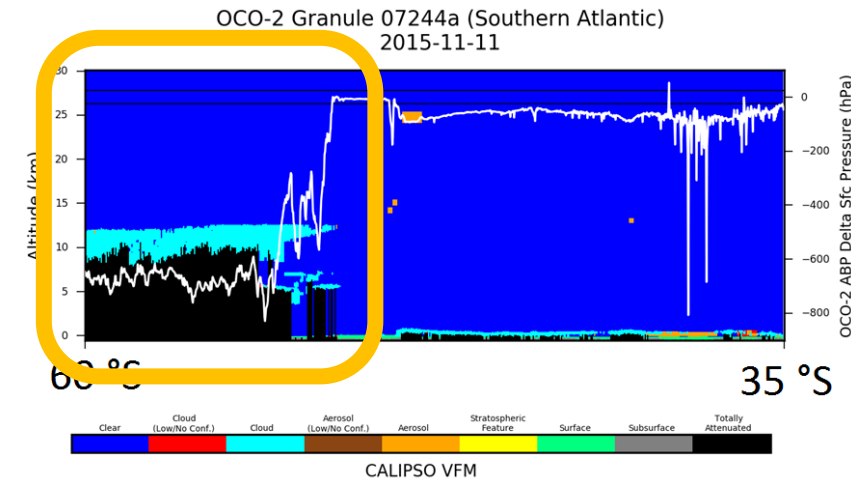
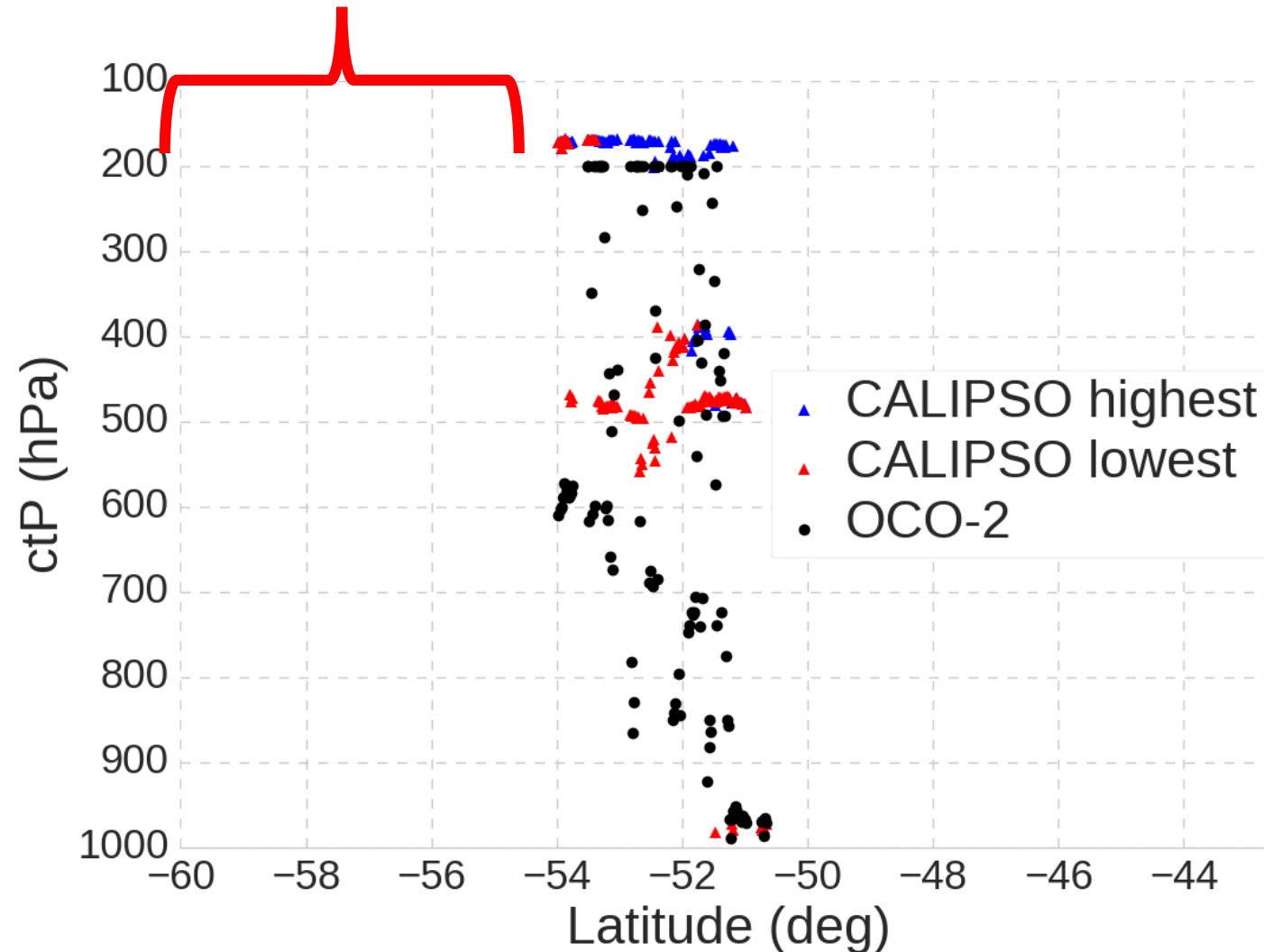


OCO-2 single-layer retrieval
in black, CALIPSO, colours

(8) OCO-2 retrievals with overlying cirrus

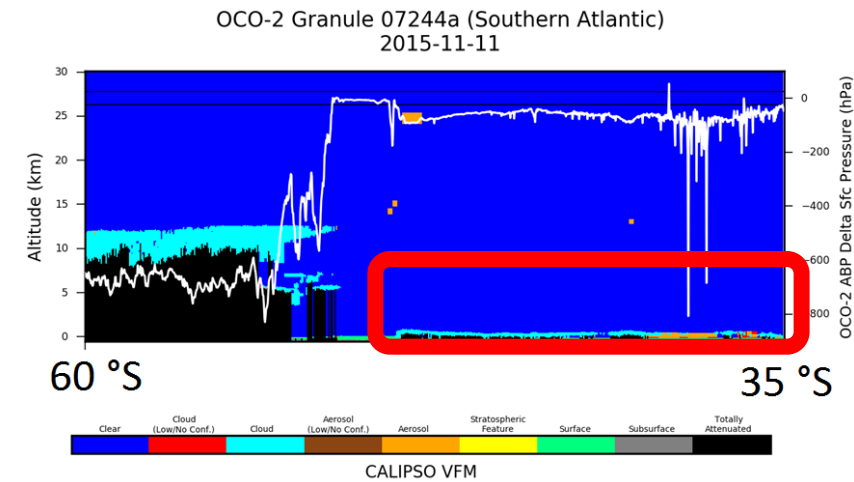
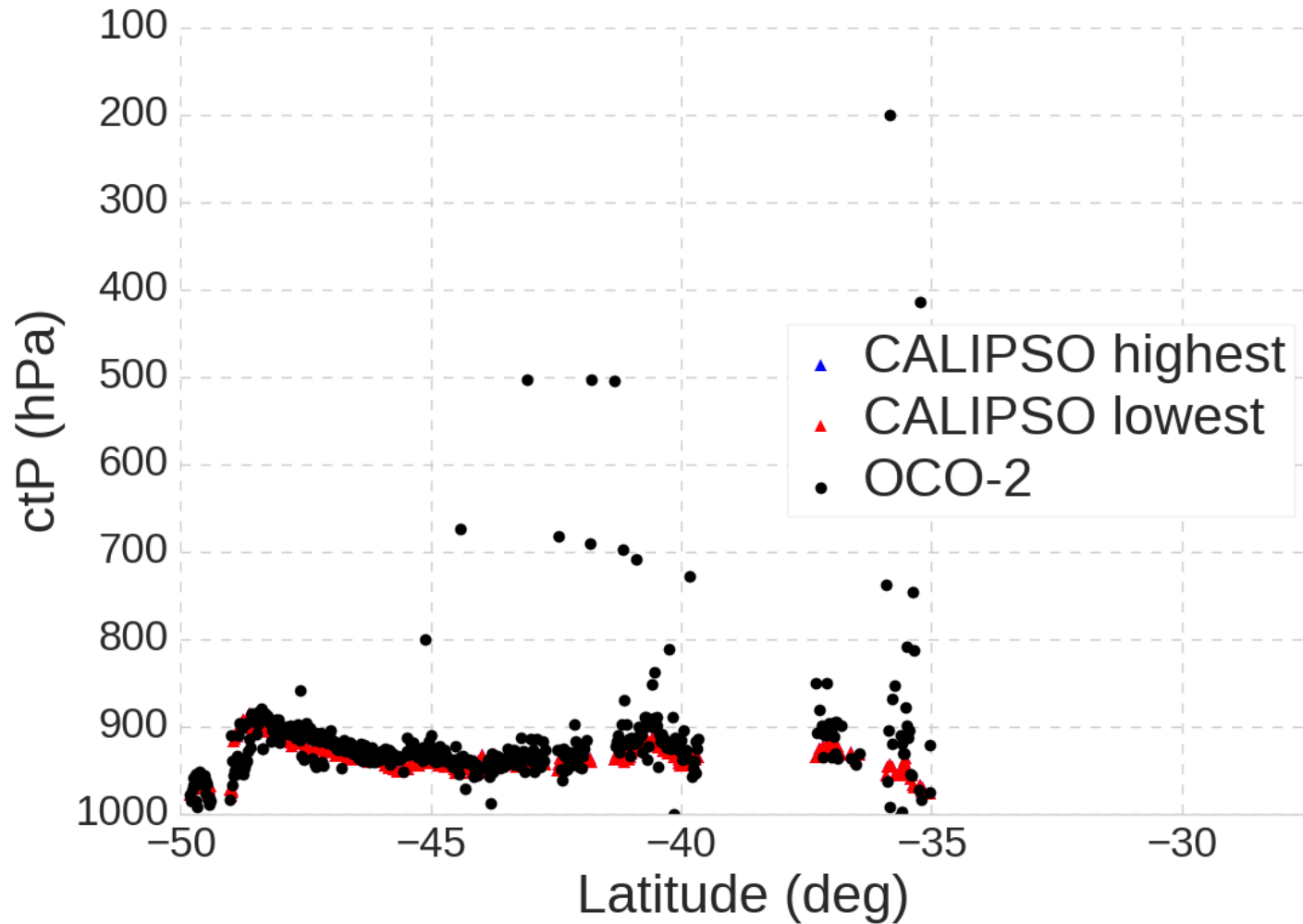
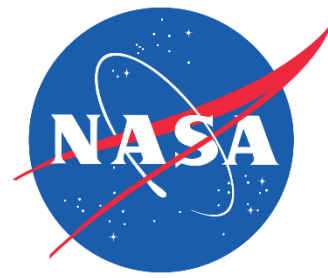


OCO-2 identifies this
bit as ice, no retrieval



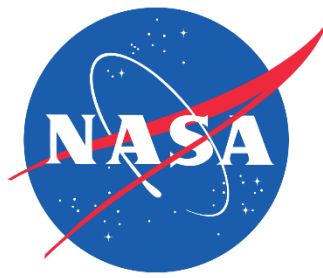
OCO-2 single-layer retrieval
in black, CALIPSO, colours

(9) OCO-2 retrieval of boundary layer cloud

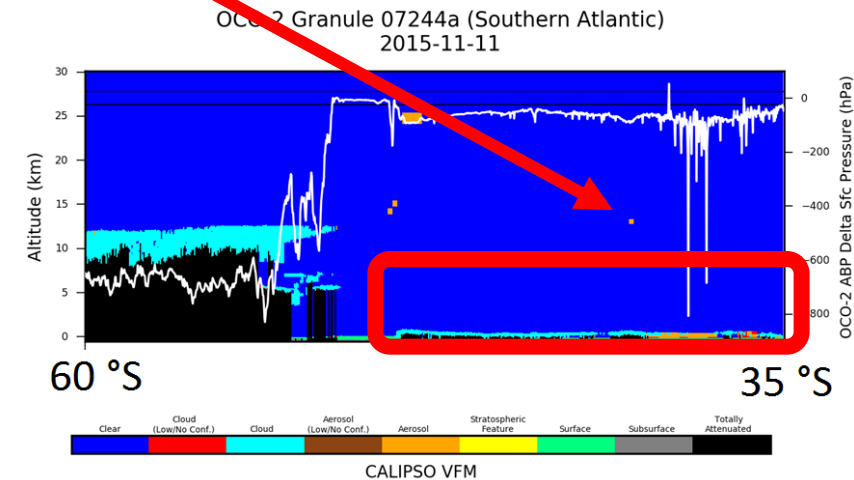
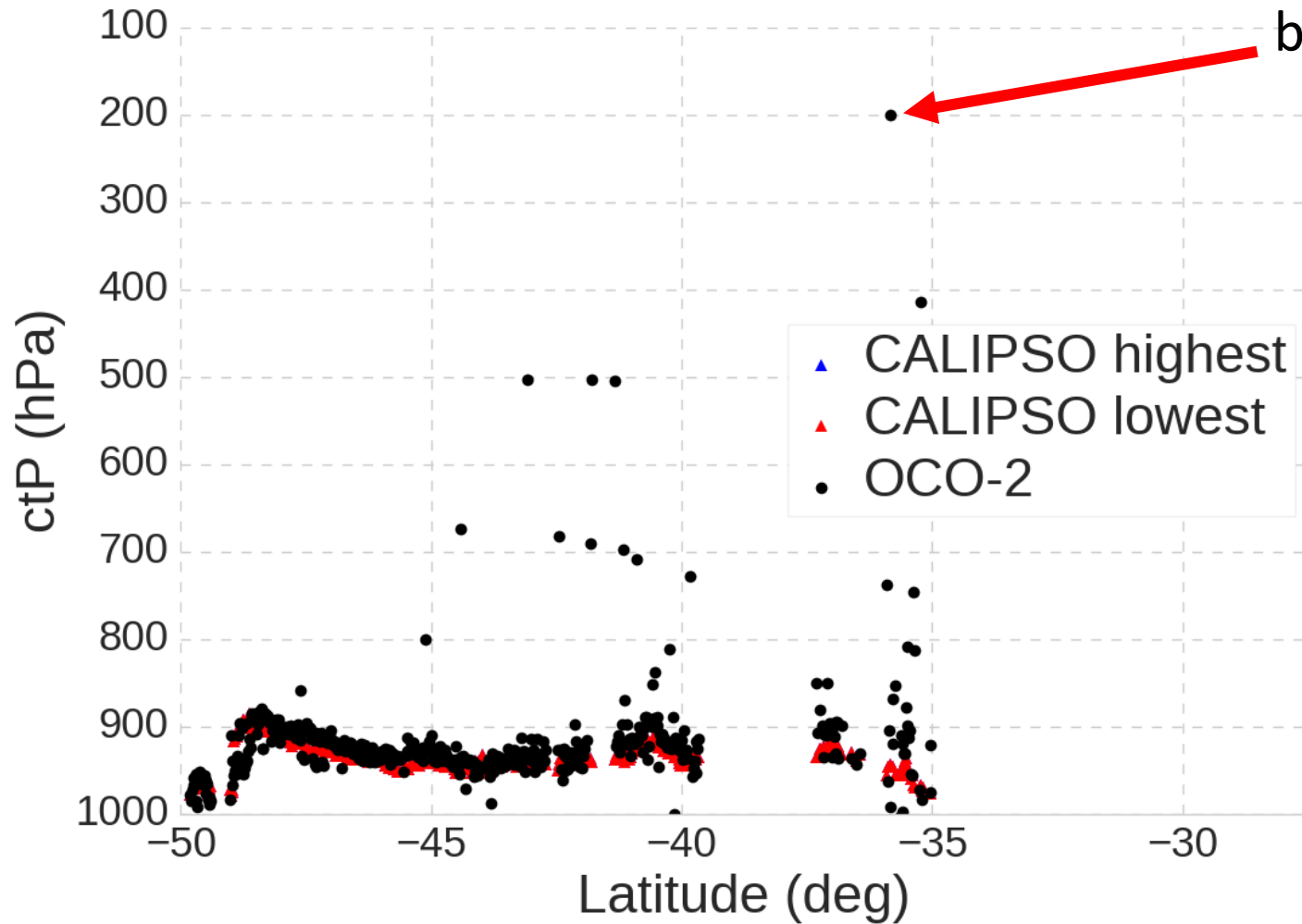


OCO-2 single-layer retrieval
in black, CALIPSO, colours

(9) OCO-2 retrieval of boundary layer cloud

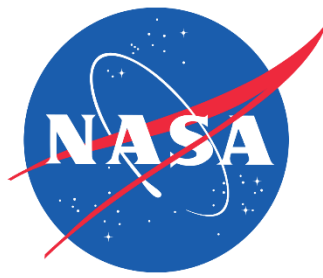


Some outliers, could be aerosol?

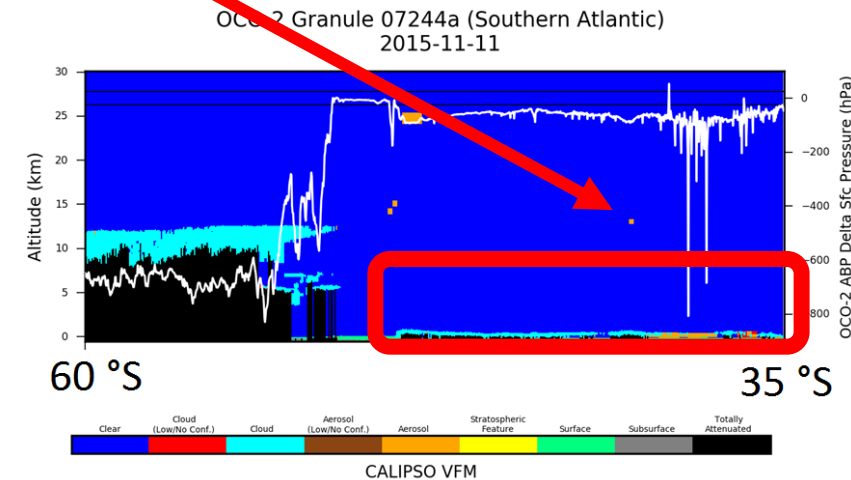
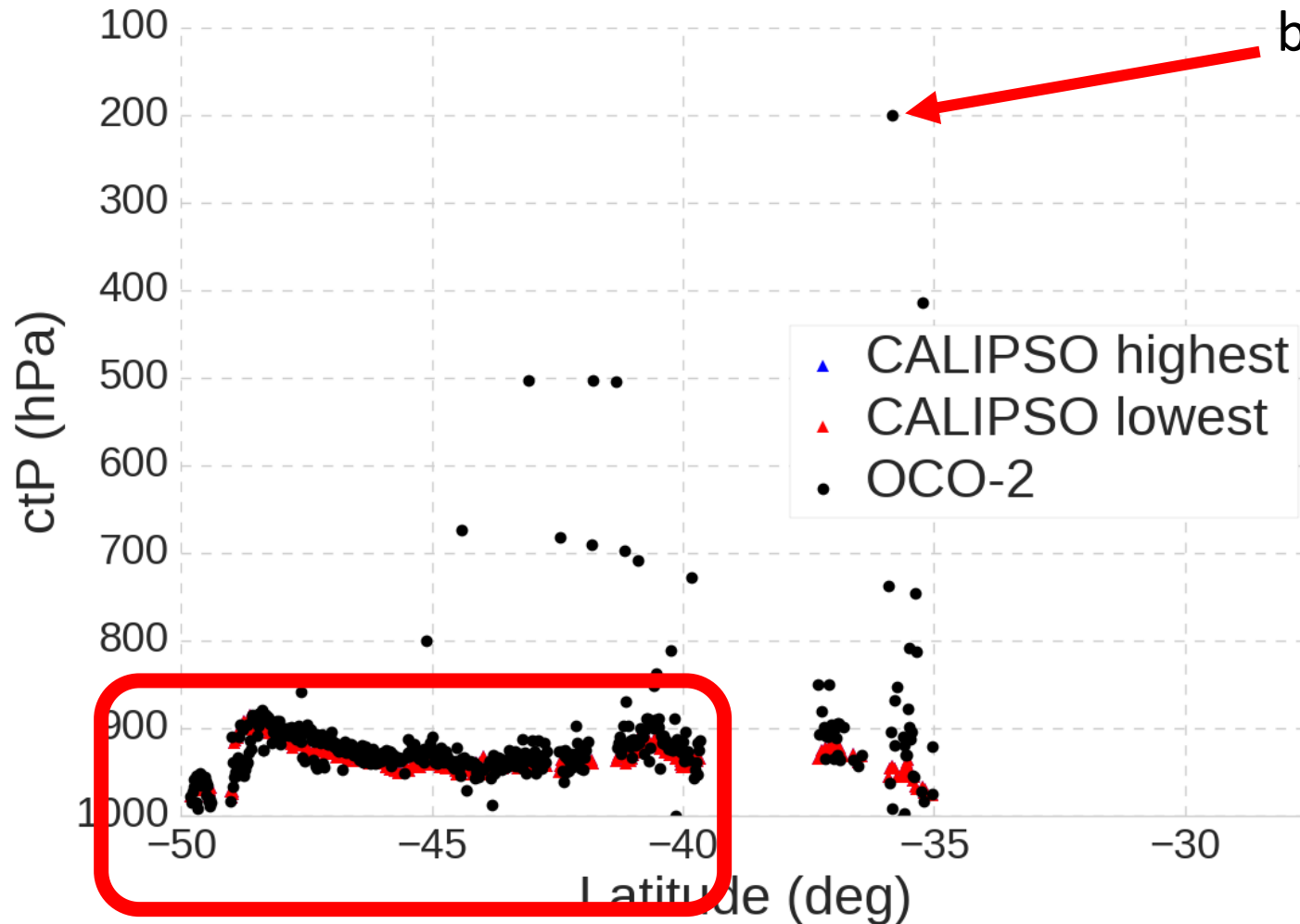


OCO-2 single-layer retrieval in black, CALIPSO, colours

(9) OCO-2 retrieval of boundary layer cloud



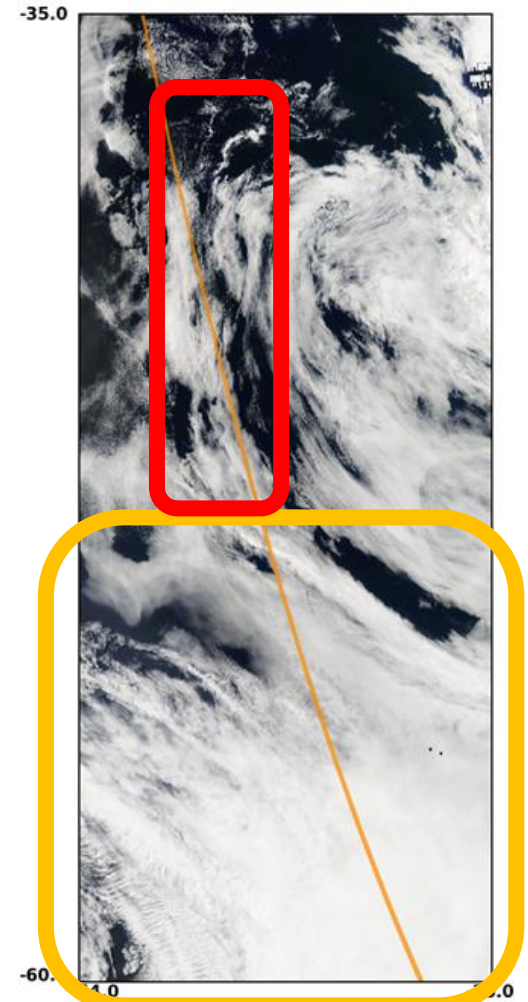
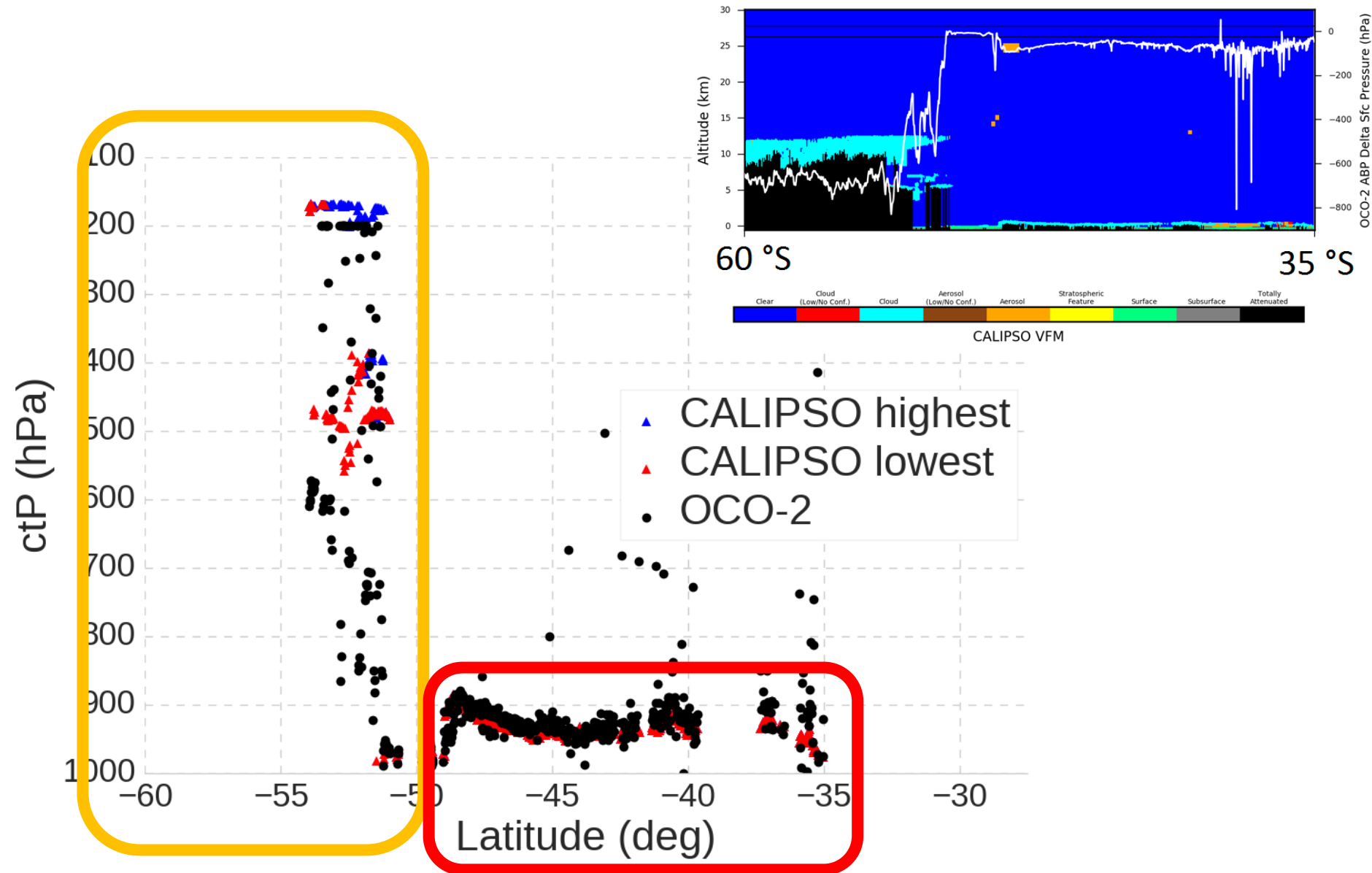
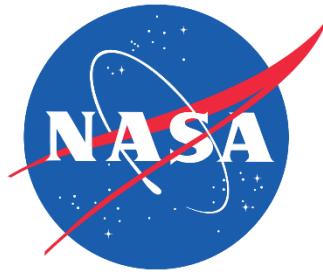
Some outliers, could be aerosol?

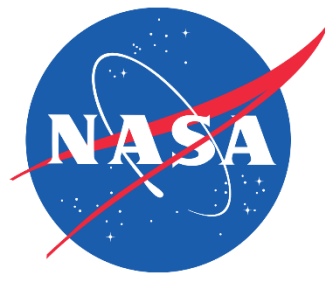


OCO-2 single-layer retrieval in black, CALIPSO, colours

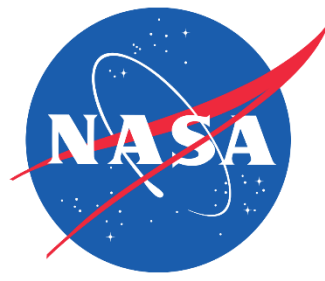
But the low cloud deck looks ok...

(10) Region summary



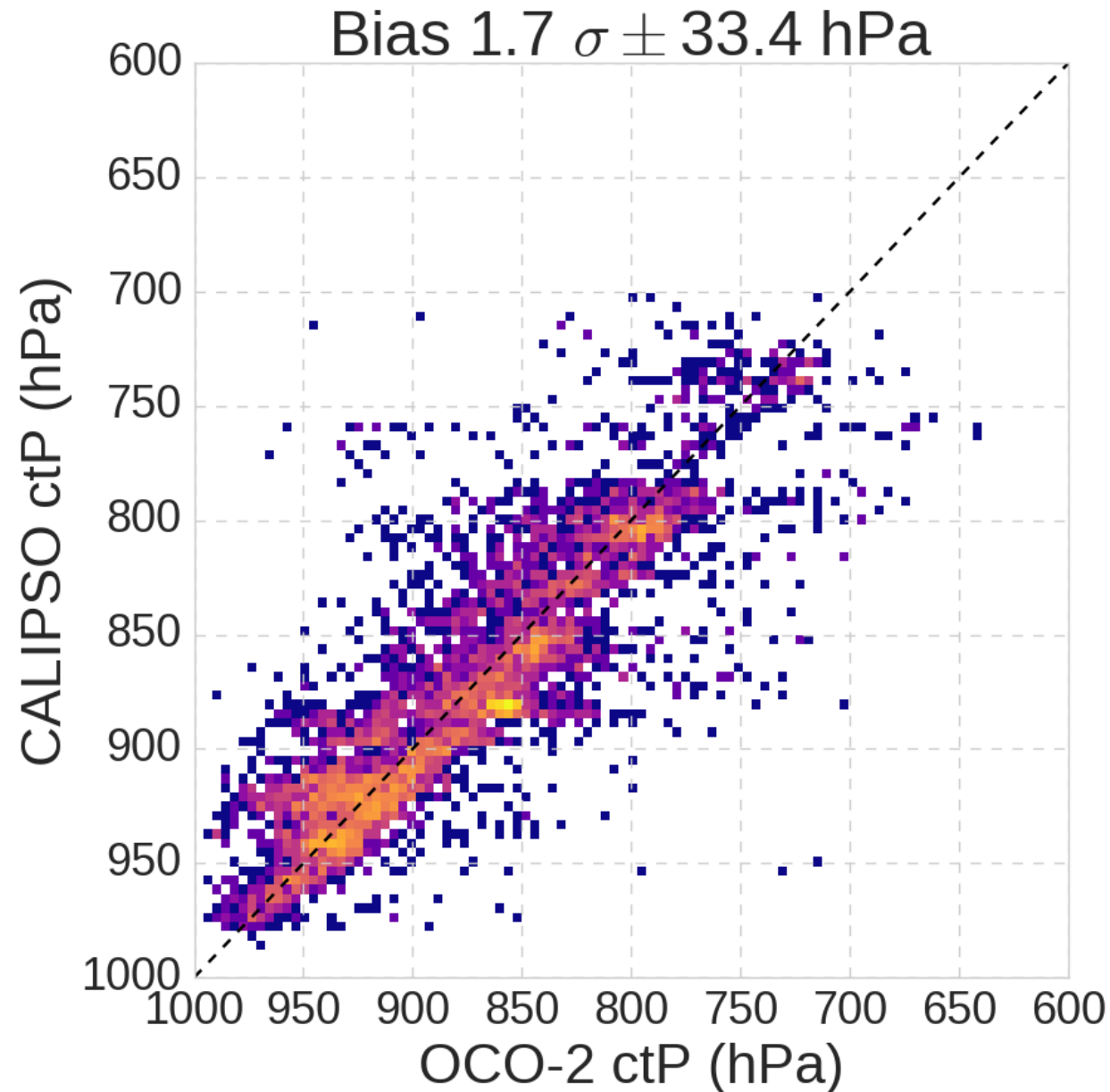
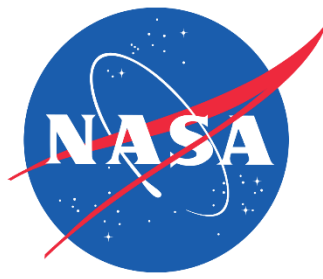


NOW THICKNESS



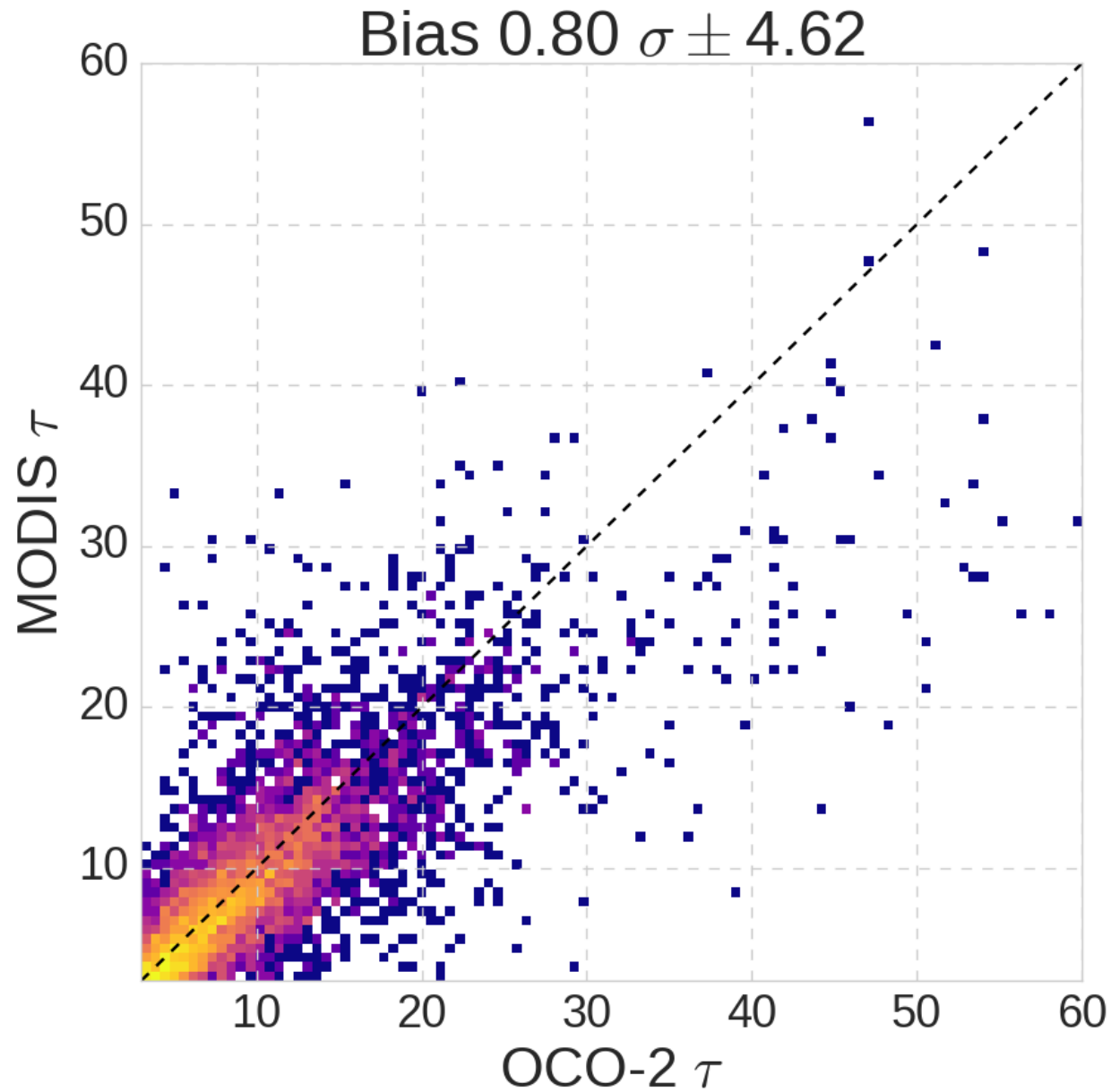
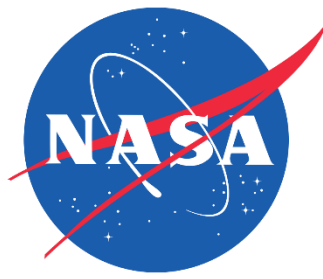
LET'S LOOK AT REFF

(13) Stratus cloud-top pressure, OCO-2 v CALIPSO



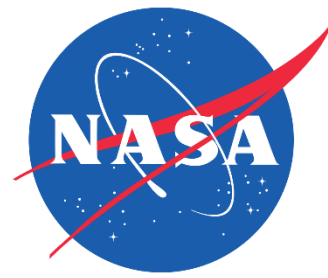
Converged “strato”
cases, $N = 5247$
(70 % converge)

(14) Stratus optical depth, OCO-2 v MODIS

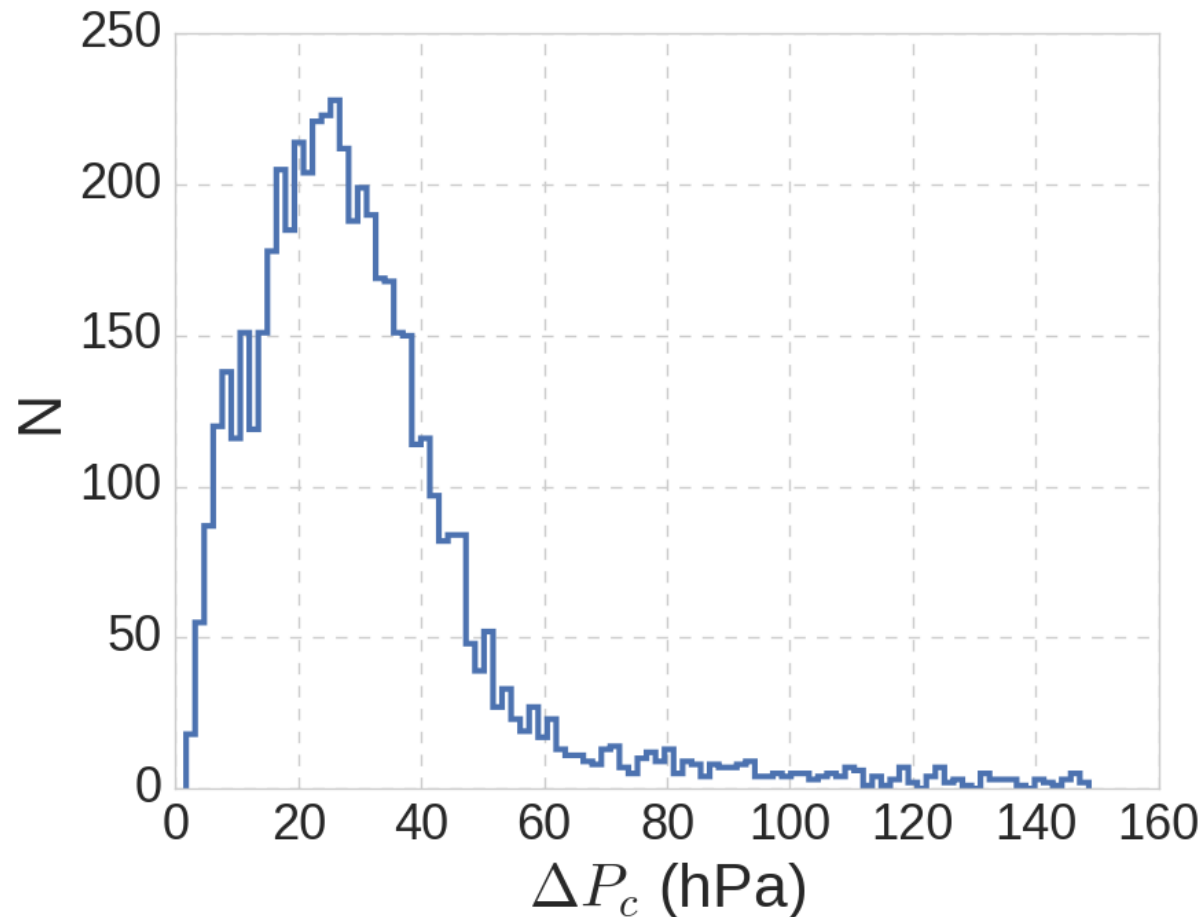


Converged “strato”
cases, $N = 5247$
(70 % converge)

(15) First results of cloud pressure thickness



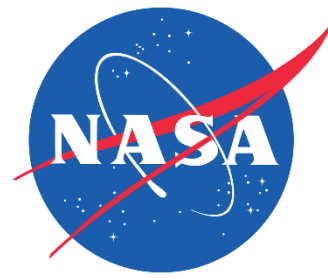
Histogram of cloud pressure thickness from converged stratus cases



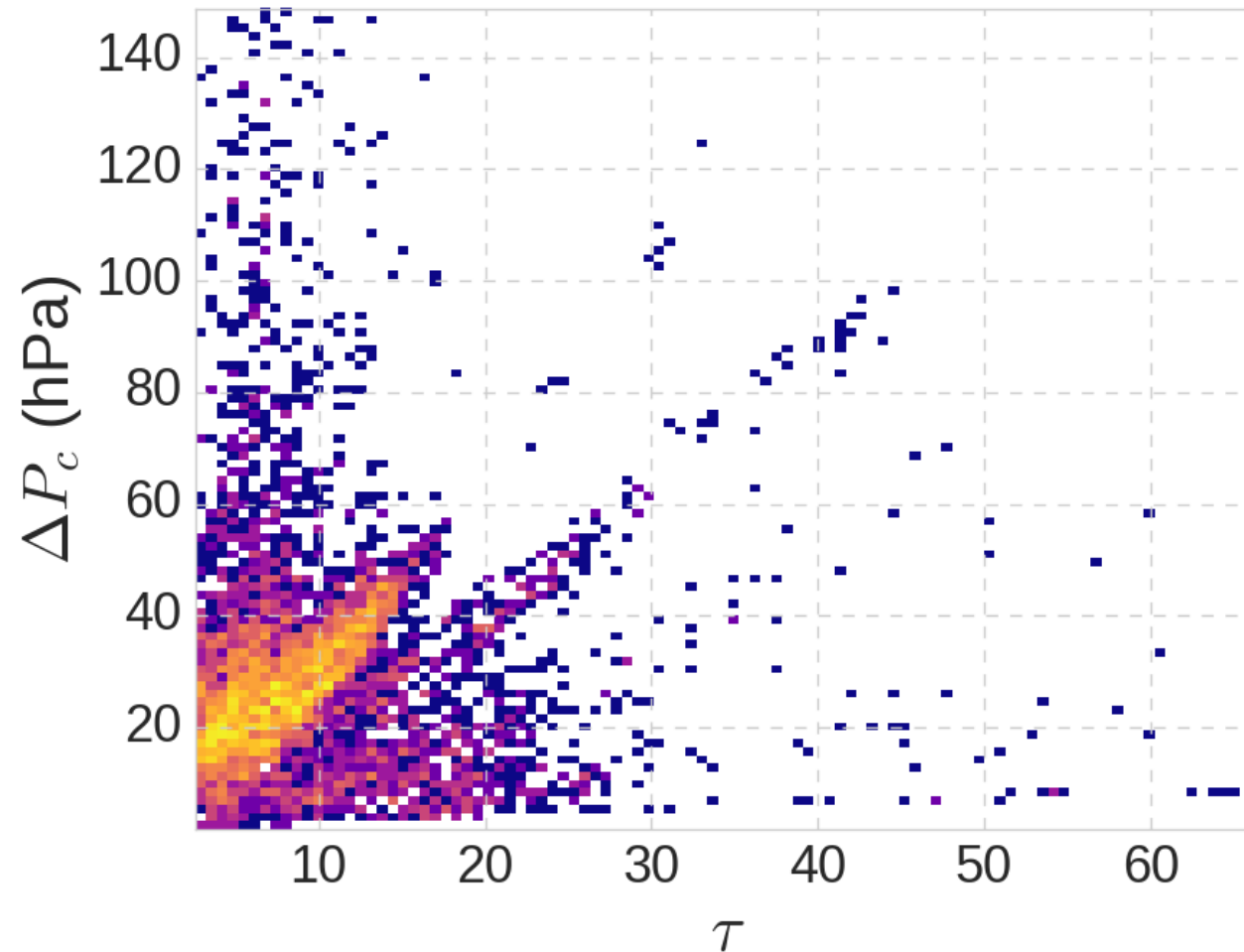
Thickness:
Mean: 36 hPa
Stdev: ± 16 hPa

τ :
Mean: 11
Stdev: 6

(16) First results of cloud pressure thickness

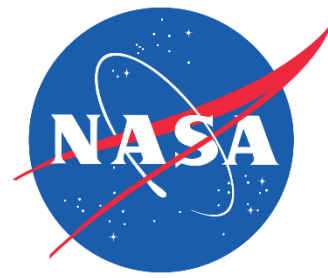


Joint $\tau - \Delta P_c$ from converged OCO-2 marine stratus

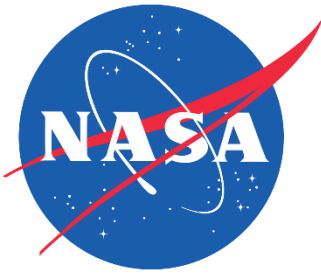


Optical depth and pressure thickness should be related, but we see some outliers here.

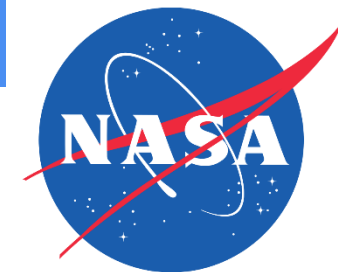
They passed convergence tests but are still unrealistic.



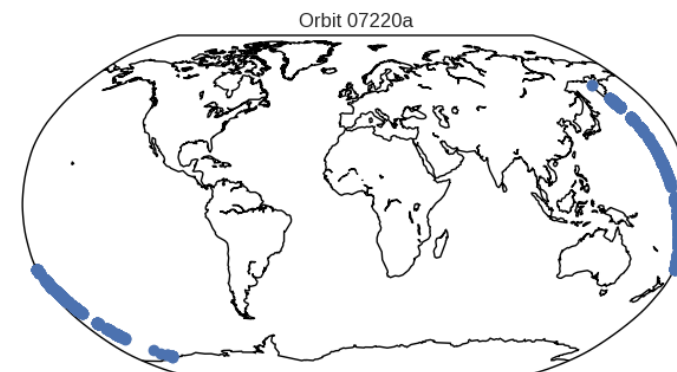
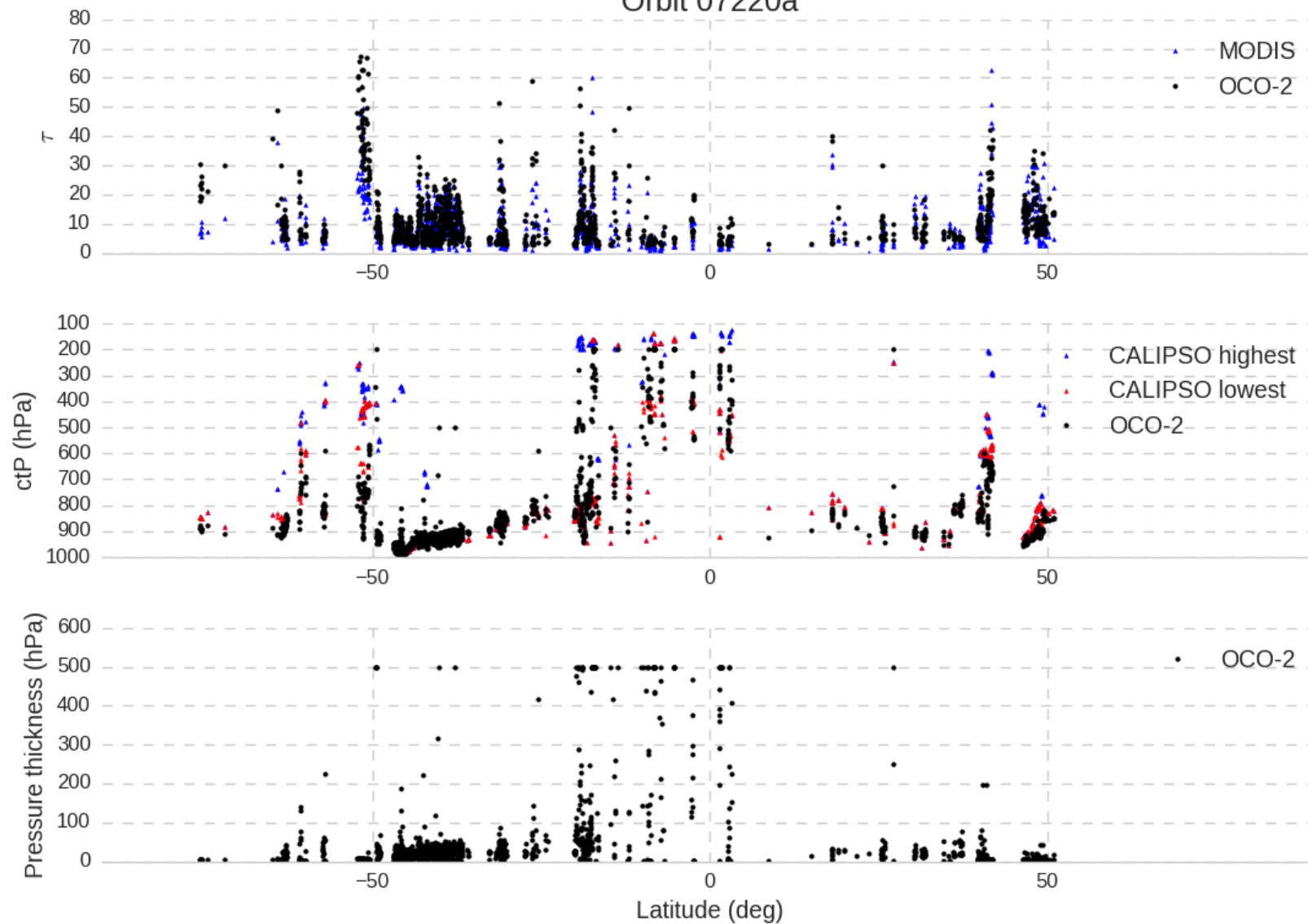
- OCO-2 retrievals of marine boundary layer clouds will be collocated with CloudSat and put on CloudSat DPC website
- $ctP-\tau$ validation looks fine v MODIS/CALIPSO
- Now: speed retrieval & improve convergence
- Later: Extend to cloud layering, over land, ice clouds + validation of thickness

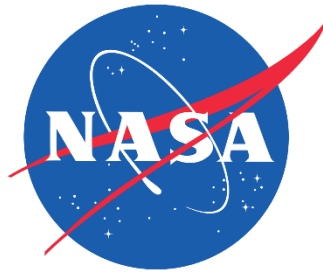


BLANK

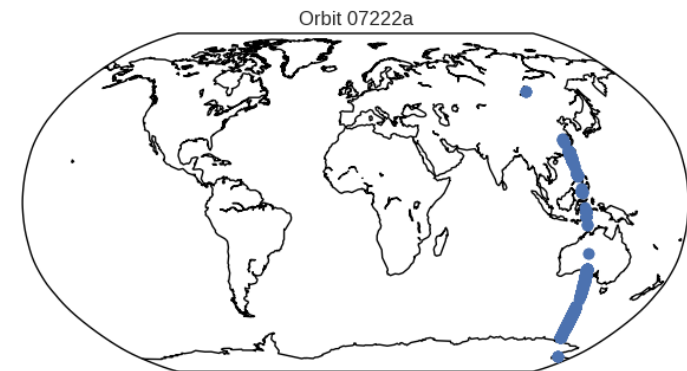
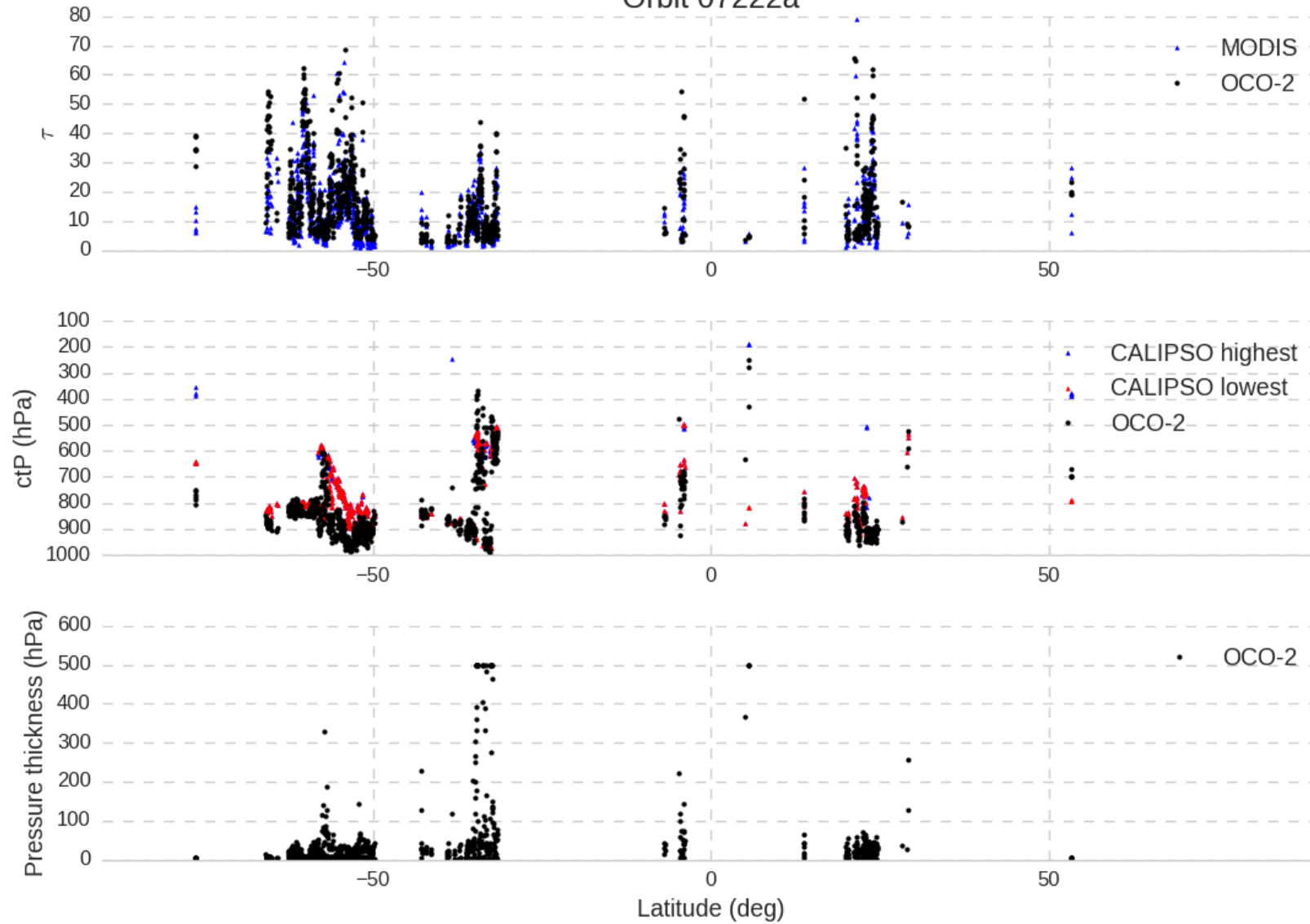


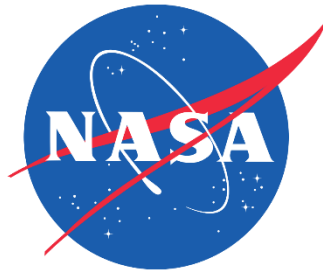
Orbit 07220a



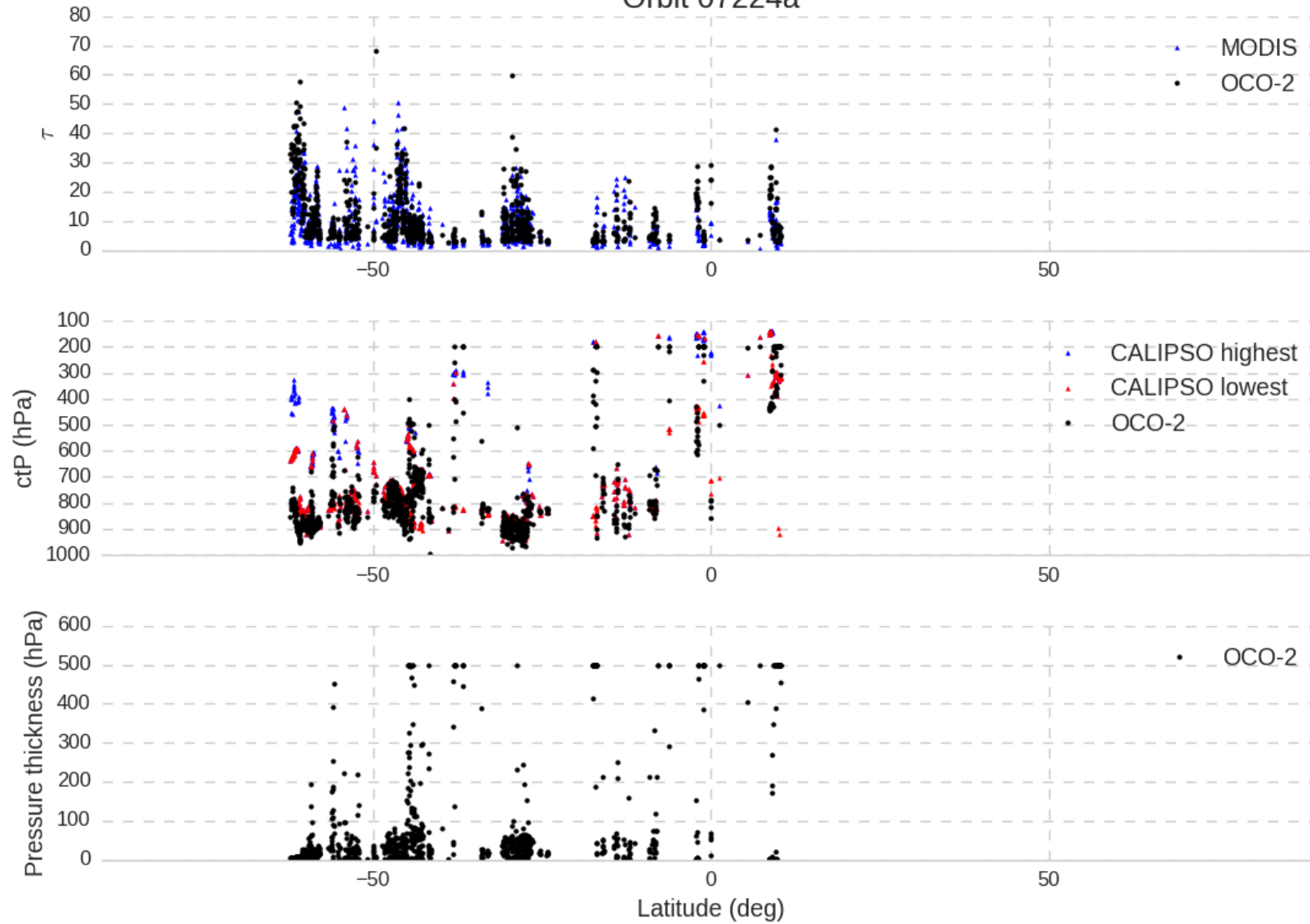


Orbit 07222a

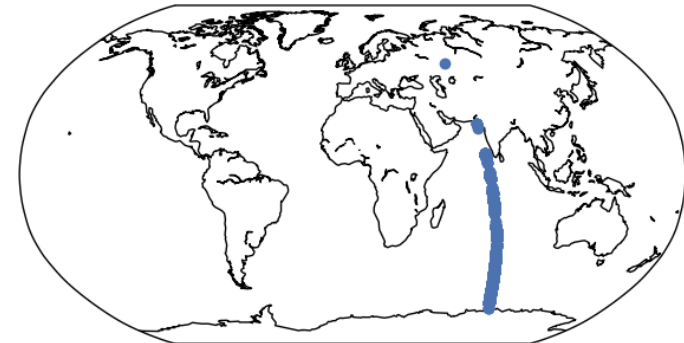


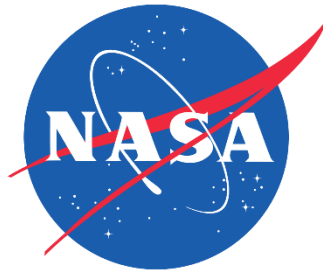


Orbit 07224a

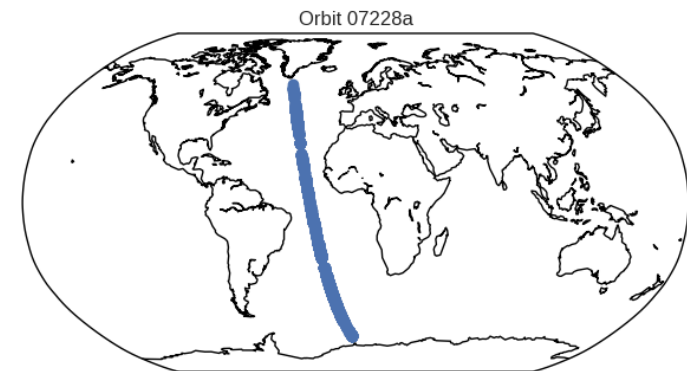
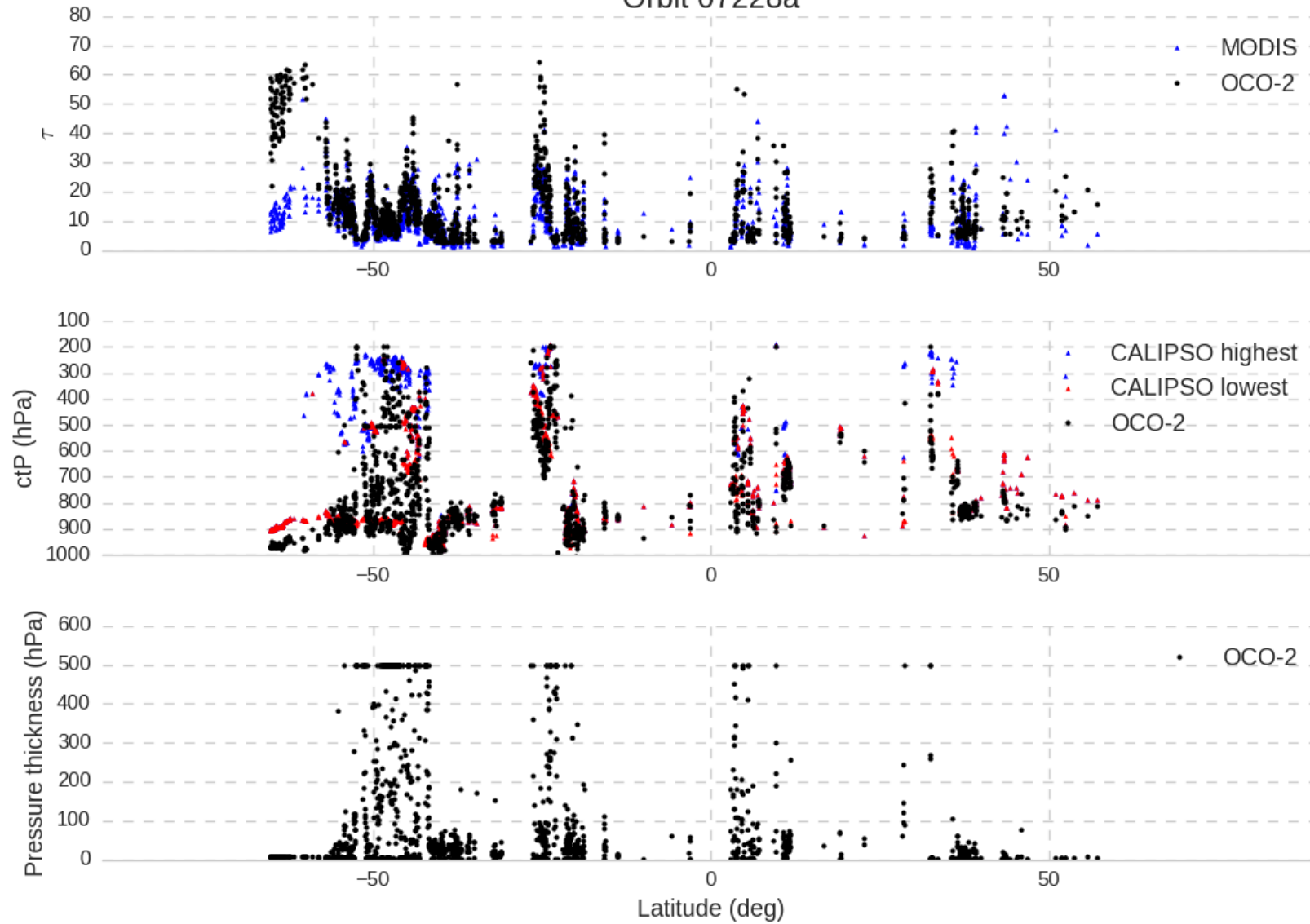


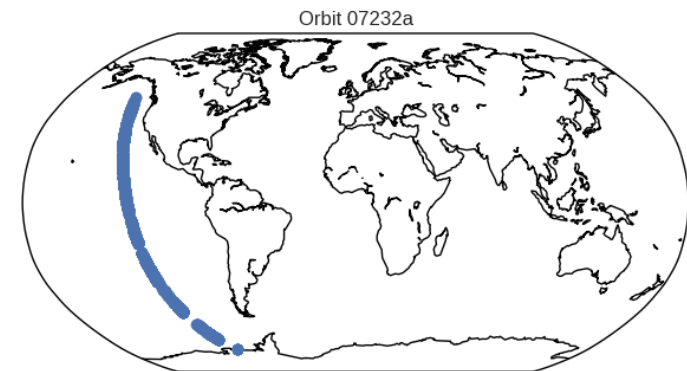
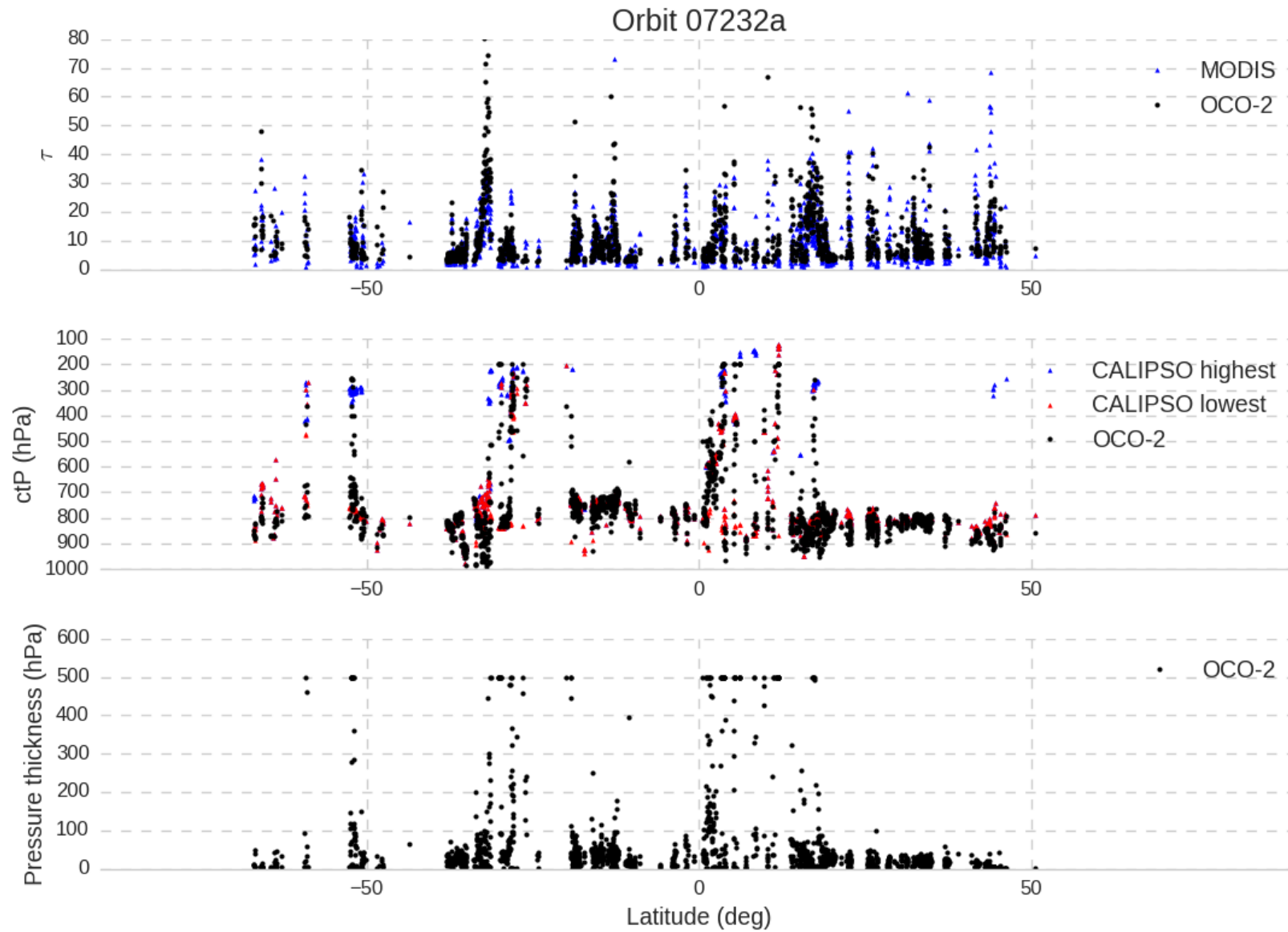
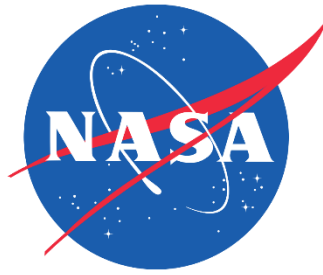
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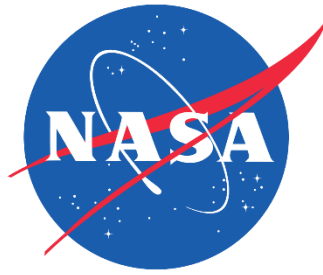




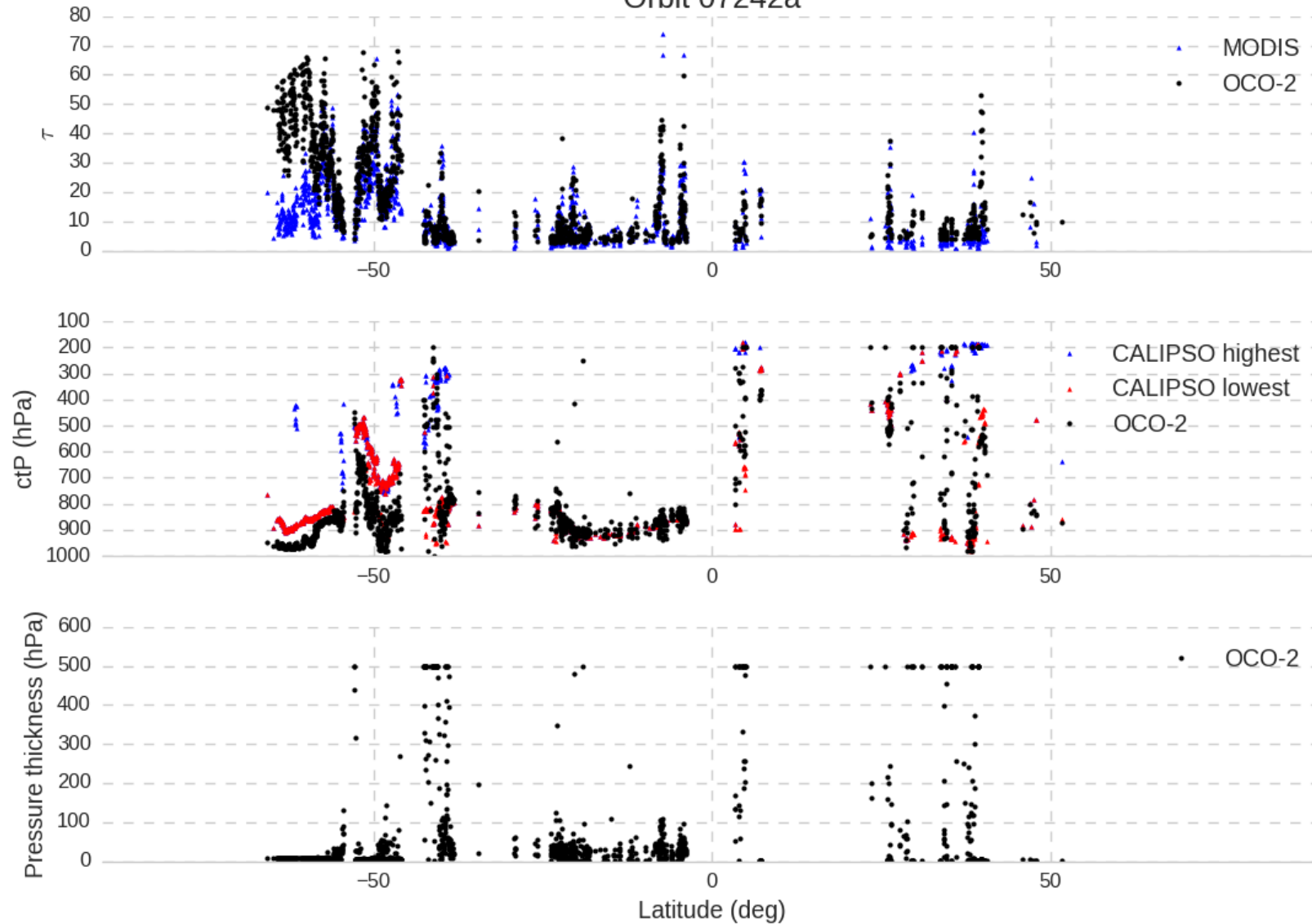
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Orbit 07242a



Orbit 07242a

